STATE OF NEW MEXICO
BEFORE THE ENVIRONMENTAL IMPROVEMENT BOARD

IN THE MATTER OF PROPOSED REGULATION
20.2.350 NMAC – *GREENHOUSE GAS CAP AND*
TRADE PROVISIONS **No. EIB 10-04 (R)**

DIRECT TESTIMONY OF FRANZ LITZ

Thank you for this opportunity to speak on this matter of great importance. I am Franz Litz, a Senior Fellow with the World Resources Institute. I am here to talk to you about cap and trade as an instrument to achieve cost-effective emissions reductions from sources of greenhouse gas emissions in the State of New Mexico.

I begin with a quick introduction to the World Resources Institute and our work. I then describe cap and trade and explain how it compares to traditional command-and-control regulation. Next I will provide a summary of how existing cap-and-trade programs have been designed and implemented in the United States and abroad. I have provided background materials I believe will be helpful to you in considering these issues as exhibits to my testimony.

I. THE WORLD RESOURCE INSTITUTE

The World Resources Institute is a non-profit environmental think tank based in Washington, D.C. that provides analysis and builds practical solutions to the world's most pressing environmental and development challenges. We work in partnership with scientists, business, governments, and non-governmental organizations in more than seventy countries to provide information, tools and analysis to address problems like climate change. My work has focused on the development of climate change and energy policies at the state and regional levels in North America, especially the design and implementation of cap-and-trade programs to reduce greenhouse gas emissions.

II. **CAP AND TRADE: WHAT, HOW, AND WHY**

Over the past several decades, cap and trade has emerged as a preferred policy tool for reducing pollution because it provides environmental certainty through a cap on overall emissions while also offering emissions sources flexibility to seek out the most cost-effective reductions. Cap and trade begins with an emissions cap covering a specified set of emissions sources. The government then issues an emissions allowance—a kind of revocable permit to emit—for each ton of emissions permitted under the cap. Emissions allowances can be distributed in a number of ways in the cap-and-trade system. Sources are subject to two fairly simple general obligations: (1) they must measure, monitor, verify and report emissions to the administrator of the program; and (2) at the end of each compliance period they must surrender allowances equal to their total emissions during the compliance period.

Because the allowances are tradable, only those sources with the lowest cost emissions reductions will reduce their emissions and sell excess allowances to other emissions sources for whom it is less expensive to buy allowances rather than reduce emissions. Overall emissions reductions occur because the emissions cap covers all sources. The location of reductions, however, is determined by the emissions trading market according to where the reductions are least expensive.

Attached as NMED-Litz Exhibit 1 to this testimony is a summary of cap-and-trade principles entitled "Cap and Trade 101" produced by the Center for American Progress that provides a step-by-step description of how cap and trade works.

III. CAP AND TRADE VERSUS COMMAND AND CONTROL

Cap-and-trade programs have several advantages over more traditional "command-and-control" regulatory programs. Command-and-control programs generally require all emissions sources within specified categories to meet specific emissions limitations or to install specific emissions abatement technology. For example, the federal New Source Performance Standards applicable to new and substantially modified steam electric generating units require that such units not emit more than 1.2 pounds of sulfur dioxide per million British thermal units of heat input (lbs/MMBtu). 40 CFR Part 60, Subpart Da. This standard applies to every unit and not just those units for which pollution control is the most cost-effective. While cost is often a consideration in establishing such command-and-control requirements, regulatory requirements that apply across all similar sources do not have the inherent flexibility of cap and trade, which allows the sources for whom reductions are least expensive to reduce more than sources for whom reductions are more expensive. Attached as NMED-Litz Exhibit 2 to my testimony is a report by Dr. Denny Ellerman of the Massachusetts Institute of Technology (MIT) entitled "Emissions Trading in the United States: Experience, Lessons and Considerations for Greenhouse Gases". Table 1 from the Ellerman paper is reproduced below to show the programs examined in the paper.

Table 1

Summary of Emissions Trading Programs

Program	Agency	Type	Emissions	Source	Scope	Year
EPA Emissions Trading Program	U.S. EPA	Reduction Credit, Averaging	Various	Stationary	U.S.	1979–Present
Lead-in-Gasoline	U.S. EPA	Averaging	Lead	Gasoline	U.S.	1982–87
Acid Rain Trading	U.S. EPA	Cap-and-Trade, Reduction Credit	SO_2	Electricity Generation	U.S.	1995–Present
RECLAIM	South Coast Air Quality Management District	Cap-and-Trade	NO_X, SO_2	Stationary	Los Angeles Basin	1994–Present
Averaging, Banking, and Trading (ABT)	U.S. EPA	Averaging	Various	Mobile	U.S.	1991–Present
Northeast NO_X Budget Trading	U.S. EPA, 12 states, and D.C.	Cap-and-Trade	NO_X	Stationary	Northeastern U.S.	1999–Present

IV. EXISTING CAP-AND-TRADE PROGRAMS

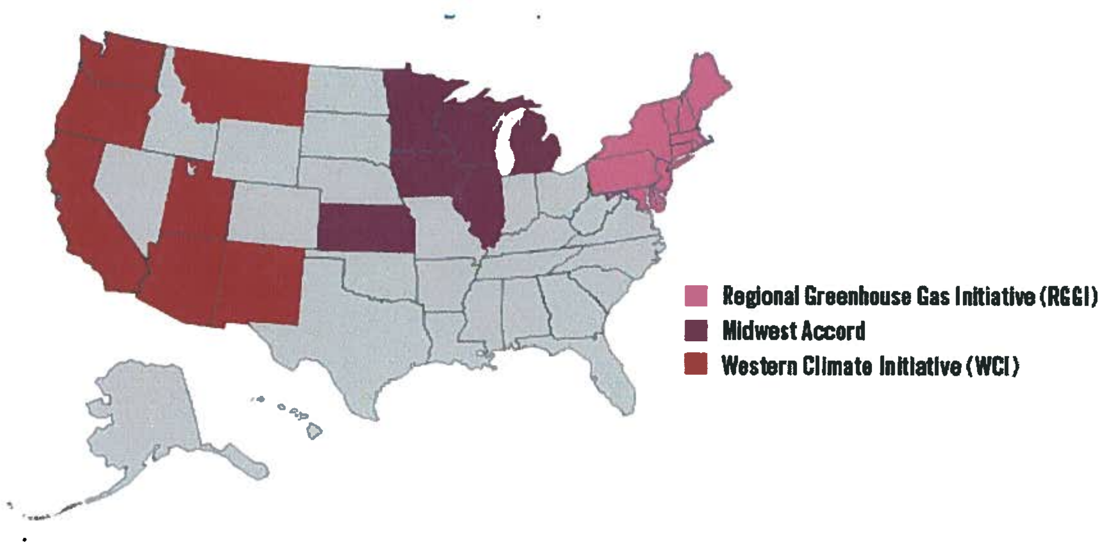
We know that cap and trade can be a cost-effective and environmentally sound approach to reducing emissions because the approach has been successful in a number of existing contexts. The following is a list of existing programs:

- The Acid Rain Emissions Trading Program in the United States;
- The NOx Budget and NOx SIP Call cap-and-trade programs in the eastern United States;
- The Regional Greenhouse Gas Initiative (RGGI) in the Northeast United States; and
- The European Emissions Trading System (EU ETS) in the member states of the European Union.

The Ellerman paper referenced above analyzes the results of the U.S. Acid Rain cap-and-trade program and the NOx Budget and NOx SIP Call programs. I have also attached as NMED-Litz Exhibit 3 an evaluation of the RGGI program after its first year in operation. Finally, NMED-Litz Exhibit 4 contains a second Ellerman paper evaluating the experience with the EU ETS.

V. PROPOSED REGIONAL PROGRAMS IN THE UNITED STATES

In addition to the programs listed above and evaluated in the papers attached as exhibits to my testimony, two additional regional greenhouse gas emissions trading programs are in the development phase in North America, as depicted in the figure below.



Both the Western Climate Initiative and the Midwestern Greenhouse Gas Reduction Accord seek to achieve emissions reductions using cap and trade. The table attached as NMED-Litz Exhibit 5 to my testimony compares the features of the three regional trading programs.

Center for American Progress

Cap and Trade 101

What is Cap and Trade?

The goal: To steadily reduce carbon dioxide and other greenhouse gas emissions economy-wide in a cost-effective manner.

The cap: Each large-scale emitter, or company, will have a limit on the amount of greenhouse gas that it can emit. The firm must have an "emissions permit" for every ton of carbon dioxide it releases into the atmosphere. These permits set an enforceable limit, or cap, on the amount of greenhouse gas pollution that the company is allowed to emit. Over time, the limits become stricter, allowing less and less pollution, until the ultimate reduction goal is met. This is similar to the cap and trade program enacted by the Clean Air Act of 1990, which reduced the sulfur emissions that cause acid rain, and it met the goals at a much lower cost than industry or government predicted.

The trade: It will be relatively cheaper or easier for some companies to reduce their emissions below their required limit than others. These more efficient companies, who emit less than their allowance, can sell their extra permits to companies that are not able to make reductions as easily. This creates a system that guarantees a set level of overall reductions, while rewarding the most efficient companies and ensuring that the cap can be met at the lowest possible cost to the economy.

The profits: If the federal government auctions the emissions permits to the companies required to reduce their emissions, it would create a large and dependable revenue stream. These financial resources could be used to achieve critical public policy objectives related to climate change mitigation and economic development. The federal government can also choose to "grandfather" allowances to the polluting firms by handing them out free based on historic or projected emissions. This would give the most benefits to those companies with higher baseline emissions that have historically done the least to reduce their pollution.

What Would a Successful Cap-and-Trade Program Look Like?

The goal: To limit the rise in global temperature to approximately 2.0 degrees Celsius (3.6 degrees Fahrenheit) above pre-industrial levels by 2050 by reducing carbon dioxide and other emissions from companies as part of a larger plan for curbing global warming.

The cap: To achieve this goal, the U.S. government should steadily tighten the cap until emissions are reduced to 80 percent below 1990 levels by 2050. Businesses would have to obtain

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EXHIBIT 1

permits entitling them to emit a certain quantity of carbon dioxide or its equivalent in other greenhouse gases. All permits would be auctioned off by the government. Emissions permits in the near term would likely fall in the range of $10 to $15 per metric ton of carbon dioxide or its equivalent.

The trade: Companies unable to meet their emissions quotas could purchase allowances from other companies that have acquired more permits than they need to account for their emissions. The cost of buying and selling these credits would be determined by the marketplace, which over time would reduce the cost of trading the credits as trading becomes more widespread and efficient.

The profits: Initial estimates by the Congressional Budget Office project that an economy-wide cap-and-trade program would generate at least $50 billion per year, but could reach up to $300 billion. Approximately 10 percent of this revenue should be allocated to help offset costs to businesses and shareholders of affected industries. Of the remaining revenue, approximately half should be devoted to help offset any energy price increases for low- and middle-income Americans that may occur as a result of the transition to more efficient energy sources. The other half of the remaining revenue should be used to invest in renewable energy, efficiency, low-carbon transportation technologies, green-collar job training, and the transition to a low-carbon economy. Some resources should also be invested in the energy, environment, and infrastructure sectors in developing nations to alleviate energy poverty with low-carbon energy systems and help these nations adapt to the inevitable effects of global warming. Revenues from the permit auction would essentially be "recycled" back into the economy to facilitate the transition to an efficient, low-carbon energy economy and ensure that consumers are not unduly burdened by potentially higher energy costs.

policy

Emissions trading in the U.S.

Experience, Lessons, and Considerations for Greenhouse Gases

A. Denny Ellerman
Paul L. Joskow
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

David Harrison, Jr.
NATIONAL ECONOMIC RESEARCH ASSOCIATES, INC.

PEW CENTER ON Global CLIMATE CHANGE

NMED-LITZ
EXHIBIT 2

Emissions trading in the U.S.

Experience, Lessons, and Considerations for Greenhouse Gases

Prepared for the Pew Center on Global Climate Change

by

A. Denny Ellerman
Paul L. Joskow
Massachusetts Institute of Technology

David Harrison, Jr.
National Economic Research Associates, Inc.

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Contents

Foreword *Eileen Claussen, President, Pew Center on Global Climate Change*

In recent years, emissions trading has become an important element of programs to control air pollution. Experience indicates that an emissions trading program, if designed and implemented effectively, can achieve environmental goals faster and at lower costs than traditional command-and-control alternatives. Under such a program, emissions are capped but sources have the flexibility to find and apply the lowest-cost methods for reducing pollution. A cap-and-trade program is especially attractive for controlling global pollutants such as greenhouse gases because their warming effects are the same regardless of where they are emitted, the costs of reducing emissions vary widely by source, and the cap ensures that the environmental goal is attained.

Report authors Denny Ellerman and Paul Joskow of the Massachusetts Institute of Technology and David Harrison of National Economic Research Associates, Inc. review six diverse U.S. emissions trading programs, drawing general lessons for future applications and discussing considerations for controlling greenhouse gas emissions. The authors derive five key lessons from this experience. First, emissions trading has been successful in its major objective of lowering the cost of meeting emission reduction goals. Second, the use of emissions trading has enhanced—not compromised—the achievement of environmental goals. Third, emissions trading has worked best when the allowances or credits being traded are clearly defined and tradable without case-by-case certification. Fourth, banking has played an important role in improving the economic and environmental performance of emissions trading programs. Finally, while the initial allocation of allowances in cap-and-trade programs is important from a distributional perspective, the method of allocation generally does not impair the program's potential cost savings or environmental performance.

With growing Congressional interest in programs to address climate change—including the recent introduction of economy-wide cap-and-trade legislation controlling greenhouse gas emissions—the application of lessons learned from previous emissions trading programs is timely. In addition to this review, the Pew Center is simultaneously releasing a complementary report, *Designing a Mandatory Greenhouse Gas Reduction Program for the U.S.*, which examines additional options for designing a domestic climate change program.

The authors and the Pew Center are grateful to Dallas Burtraw and Tom Tietenberg for reviewing a previous draft of this report. The authors also wish to acknowledge Henry Jacoby, Juan-Pablo Montero, Daniel Radov, and Eric Haxthausen for their contributions to various parts of the report, and James Patchett and Warren Herold for their research assistance.

Executive Summary

Emissions trading has emerged over the last two decades as a popular policy tool for controlling air pollution. Indeed, most major air quality improvement initiatives in the United States now include emissions trading as a component of emissions control programs. The primary attraction of emissions trading is that a properly designed program provides a framework to meet emissions reduction goals at the lowest possible cost. It does so by giving emissions sources the flexibility to find and apply the lowest-cost methods for reducing pollution. Emission sources with low-cost compliance options have an incentive to reduce emissions more than they would under command-and-control regulation. By trading emission credits and allowances to high-cost compliance sources, which can then reduce emissions less, cost-effective emission reductions are achieved by both parties. When inter-temporal trading is allowed, sources can also reduce emissions early, accumulating credits or allowances that can be used for compliance in future periods if this reduces cumulative compliance costs. Accordingly, cap-and-trade programs achieve the greatest cost savings when the costs of controlling emissions vary widely across sources or over time. In practice, well-designed emissions trading programs also have achieved environmental goals more quickly and with greater confidence than more costly command-and-control alternatives.

Emissions trading has achieved prominence beyond the United States largely in the context of discussions regarding implementation of the Kyoto Protocol, a proposed international agreement to control emissions of carbon dioxide (CO_2) and other greenhouse gases. The Kyoto Protocol provides for the use of various emissions trading mechanisms at the international level. Some countries already are developing emissions trading programs while the process of ratifying the Protocol moves forward. Both the United Kingdom and Denmark have instituted greenhouse gas (GHG) emissions trading programs, and, in December 2002, the European environment ministers agreed on the ground rules for a European Union trading program that would begin in 2005 for large sources of CO_2 emissions (and later for other GHG emissions). Indeed, proposals to control GHG emissions in the United States also include the use of emissions trading.

The theoretical virtues of emissions trading have been recognized for many decades—the basic elements were outlined in Coase (1960) and elaborated in Dales (1968)—but actual emissions trading programs have been brought from the textbook to the policy arena mostly in the last decade. It is important to recognize, however, that while properly designed emissions trading programs can reduce the cost of meeting environmental goals, experience does not indicate that significant emissions reductions can be obtained without costs. Emissions trading can be an effective mechanism for controlling emissions by providing sources with the flexibility to select the lowest-cost opportunities for abatement, but it does not make costs disappear. Moreover, emissions trading programs must be designed properly in order to realize their potential cost-reduction and environmental compliance goals. As with any emissions control program, poor design is likely to lead to disappointing results.

Experience with emissions trading, including both the design and operation of trading programs, provides a number of general lessons for future applications. This report reviews the experience with six emissions trading programs with which one or more of the authors have considerable experience:

- The early Environmental Protection Agency (EPA) Emissions Trading programs that began in the late 1970s;
- The Lead Trading program for gasoline that was implemented in the 1980s;
- The Acid Rain program for electric industry sulfur dioxide (SO_2) emissions and the Los Angeles air basin (RECLAIM) programs for both nitrogen oxides (NO_x) and SO_2 emissions, all of which went into operation in the mid-1990s;
- The federal mobile source averaging, banking, and trading (ABT) programs that began in the early 1990s; and
- The Northeast NO_x Budget trading program, which began operations in the late 1990s.

Based on this experience, this report identifies and discusses five general lessons concerning the design and implementation of emissions trading programs, and two considerations of particular relevance for GHG applications.

General Lessons from Experience with Emissions Trading

Emissions trading has been successful in its major objective of lowering the cost of meeting emission reduction goals. Experience shows that properly designed emissions trading programs can reduce compliance costs significantly compared to command-and-control alternatives. While it is impossible to provide precise measures of cost savings compared to hypothetical control approaches that might have been applied, the available evidence suggests that the increased compliance flexibility of emissions trading yields costs savings of as much as 50 percent.

The use of emissions trading has enhanced—not compromised—the achievement of environmental goals. While some skeptics have suggested that emissions trading is a way of evading environmental requirements, experience to date with well-designed trading programs indicates that emissions trading helps achieve environmental goals in several ways.

For one thing, the achievement of required emission reductions has been accelerated when emission reduction requirements are phased-in and firms are able to bank emissions reduction credits. The Lead Trading program for gasoline, the Acid Rain program for the electric industry, the federal mobile source ABT programs, and the Northeast NO_X Budget programs each achieved environmental goals more quickly through these program design features. Moreover, giving firms with high abatement costs the flexibility to meet their compliance obligations by buying emissions allowances eliminates the rationale underlying requests for special exemptions from emissions regulations based on "hardship" and "high cost." The reduction of compliance costs has also led to instances of tighter emissions targets, in keeping with efforts to balance the costs and benefits of emissions reductions. Finally, properly designed emissions trading programs appear to provide other efficiency gains, such as greater incentives for innovation and improved emissions monitoring.

Emissions trading has worked best when allowances or credits being traded are clearly defined and tradable without case-by-case pre-certification. Several different types of emissions trading mechanisms have been implemented. Their performance has varied widely, and these variations illuminate the key features of emissions trading programs that are most likely to lead to significant cost savings while maintaining (or exceeding) environmental goals.

The term "emissions trading" is used, often very loosely, to refer to three different types of trading programs: (1) reduction credit trading, in which credits for emission reductions must be pre-certified relative to an emission standard before they can be traded; (2) emission rate averaging, in which credits and debits are certified automatically according to a set average emission rate; and (3) cap-and-trade programs, in which an overall cap is set, allowances (i.e., rights to emit a unit) equal to the cap are distributed, and sources subject to the cap are required to surrender an allowance for every unit (e.g., ton) they emit.

The turnaround in perception of emissions trading over the last decade—from a reputation as a theoretically attractive but largely impractical approach to its acceptance as a practical framework for meeting air quality goals in a cost-effective manner—largely reflects the increased use of averaging and cap-and-trade type programs. The performance of the early EPA reduction credit programs was very poor and gave "emissions trading" a bad name. These early EPA programs emphasized case-by-case pre-certification of emission reductions and were characterized by burdensome and time-consuming administrative approval processes that made trading difficult. The averaging and cap-and-trade programs have been much more successful. While the use of cap-and-trade or averaging does not guarantee success, and the problems with the reduction credit-based approach can be reduced by good design, avoiding high transaction costs associated with trade-by-trade administrative certification is critical to the success of an emissions trading program. The success of any emissions trading program also requires several additional elements: emissions levels must be readily measured, legal emissions rates or caps must be clearly specified, and compliance must be verified and enforced aggressively.

Banking has played an important role in improving the economic and environmental performance of emissions trading programs. Early advocates of emissions trading tended to emphasize gains from trading among participants (i.e., low-cost compliance sources selling credits and allowances to high-cost compliance sources) in the same time period. The experience with the programs reviewed here indicates that inter-temporal trading also has been important. The form that inter-temporal trading most often takes is credit or allowance banking, i.e., reducing emissions early and accumulating credits or allowances that can be used for compliance in future periods. Banking improves environmental performance and reduces cumulative compliance costs. Moreover, it has been particularly important in providing flexibility to deal with many uncertainties associated with an emissions trading market—production levels, compliance costs, and the many other factors that influence demand for credits or allowances. Indeed, the one major program without a substantial banking provision, the Los Angeles RECLAIM program, appears to have suffered because of its absence.

The initial allocation of allowances in cap-and-trade programs has shown that equity and political concerns can be addressed without impairing the cost savings from trading or the environmental performance of these programs. Because emissions allowances in cap-and-trade programs are valuable, their allocation has been perhaps the single most contentious issue in establishing the existing cap-and-trade programs. However, the ability to allocate this valuable commodity and thereby account for the economic impacts of new regulatory requirements has been an important means of attaining political support for more stringent emissions caps. Moreover, despite all the jockeying for allowance allotments through the political process, the allocations of allowances to firms in the major programs have not compromised environmental goals or cost savings. The three cap-and-trade programs that have been observed so far all have relied upon "grandfathering," i.e., distributing allowances without charge to sources based upon historical emissions information, which generally does not affect firms' choices regarding cost-effective emission reductions and thus the overall cost savings from emissions trading. There are other methods of allocating initial allowances—such as auctioning by the government and distributing on the basis of future information—that can affect cost savings and other overall impacts; but the major effects of the initial allocation are to distribute valuable assets in some manner and to provide effective compensation for the financial impacts of capping emissions on participating sources.

Considerations for Greenhouse Gas Control Programs

Emissions trading seems especially well-suited to be part of a program to control greenhouse gas emissions. The emissions trading programs reviewed for this report generally have spatial or temporal limitations because sources of the pollutants included in these programs—such as lead, SO_2, and NO_X—may have different environmental impacts depending on the sources' locations (e.g., upwind or downwind from population centers) and the time of the emissions (e.g., summer or winter). The concerns of trading programs associated with climate change are different because greenhouse gases are both uniformly mixed in the earth's atmosphere and long-lived. The effects of GHG emissions thus are the same regardless of where the source is located and when the emissions occur (within a broad time band). This means that emissions trading can be global in scope as well as inter-temporal, creating an opportunity for the banking of emission credits, which allows emissions to vary from year to year as long as an aggregate inter-temporal cap is achieved.

Emissions trading is also well suited for GHG emissions control because the costs of reducing emissions vary widely between individual greenhouse gases, sectors, and countries, and thus there are large potential gains from trade. While other market-based approaches, such as emissions taxes, also would provide for these cost savings, the cap-and-trade version of emissions trading has the further advantage of providing greater certainty that an emission target will be met. Moreover, GHG emissions generally can be measured using relatively inexpensive methods (e.g., fuel consumption and emission factors), rather than the expensive continuous emissions monitoring required for some existing trading programs.

Furthermore, emissions trading provides important incentives for low-cost compliance sources initially outside the program to find ways to participate, and thereby further reduce costs. This opt-in feature is useful because an environmentally and cost-effective solution for reducing concentrations of greenhouse gases should be comprehensive and global, whereas initial controls on GHG emissions will—for political reasons—likely be limited, if not to certain sectors and greenhouse gases, then almost certainly to a restricted number of countries. Therefore, an important criterion for initial measures is that they be able to induce participation by sources not yet controlled. The markets created by cap-and-trade programs provide incentives for sources outside the trading program to enter if they can provide reductions more cheaply than the market prices—a common feature of any market. Although, as discussed below, the voluntary nature of these incentives can create some problems, the ability to induce further participation is an important reason to include a market-based approach initially. Indeed, it is hard to imagine how command-and-control regulations or emissions taxes could provide similar incentives to non-participants to adopt new measures to reduce greenhouse gas emissions.

Opt-in or voluntary features have a strategic role that is likely to warrant their inclusion despite the potential problems associated with them. Experience with allowing sources not covered by mandatory emissions trading programs to "opt-in," i.e., to voluntarily assume emissions control obligations and to participate in the emissions market, has revealed a trade-off. Setting clear baselines for opting-in lowers transactions costs and thus encourages participation; but some of this participation consists of credits for calculated "reductions" that are unrelated to the trading program and actually lead to increased emissions. For example, in the Acid Rain Program, evidence indicates that many of the voluntary participants received credits for having emissions below the pre-specified baseline even though they took no abatement actions. The simple emissions baseline had been set higher than these facilities' actual emissions, so at least some of the credits they received did not represent real emissions reductions.

This experience suggests that the decision whether or not to include opt-in provisions should be determined by weighing the cost-saving benefits against the emissions-increasing potential. For greenhouse gases, the potential cost-savings benefits of including a voluntary element in the mandatory program are large because initial efforts are not likely to be comprehensive and global, as they must be eventually to achieve their environmental goals and be cost-effective. Opt-in provisions also have value in improving measurement and monitoring techniques, in familiarizing participants with the requirements of emissions trading, and more generally with inducing participation of sources outside the trading program that can offer cheaper abatement. As a result, allowing participants outside the mandatory GHG emissions control program to opt-in has a strategic value that has not been prominent in other opt-in programs. Indeed, it should be possible to learn from existing experience with opt-in programs how to reduce adverse effects while achieving cost-savings.

Viewed from a broad historical perspective, emissions trading has come a long way since the first theoretical insights forty years ago and the first tentative application almost a quarter of a century ago. Although still not the dominant form of controlling pollution in the United States or elsewhere, emissions trading is being included in an increasing number of programs and proposals throughout the world, and its role seems likely to expand in the future.

I. Introduction

Emissions trading is one of several market-based approaches that theoretically should improve the performance of regulatory regimes designed to improve air quality by giving sources the flexibility to achieve emissions constraints more cheaply than ***command-and-control*** *alternatives.* (Terms in bold are defined in the Glossary at the end of the report.) The other major approach to internalizing pollution externalities efficiently is to apply emissions fees (or "environmental taxes"), in which sources must pay a fee to the government for each unit of emissions they produce to reflect the emissions' social costs. There are obvious differences between these two types—emissions trading typically sets the emission target and leaves the market price of emission rights or **credits** to vary, while emissions taxes set prices and allow realized emissions to vary. Yet both approaches give firms the flexibility needed to achieve environmental goals in the most cost-effective manner.

The first full treatment of the emissions trading approach was in a small volume by John Dales published in 1968, although the basic concept can be traced to an article in 1960 by Ronald Coase. Over the last two decades, regulators have developed specific emissions trading programs that allow us to assess the performance of different program designs and draw lessons for the application of emissions trading to additional environmental problems, including the control of **greenhouse gases.**

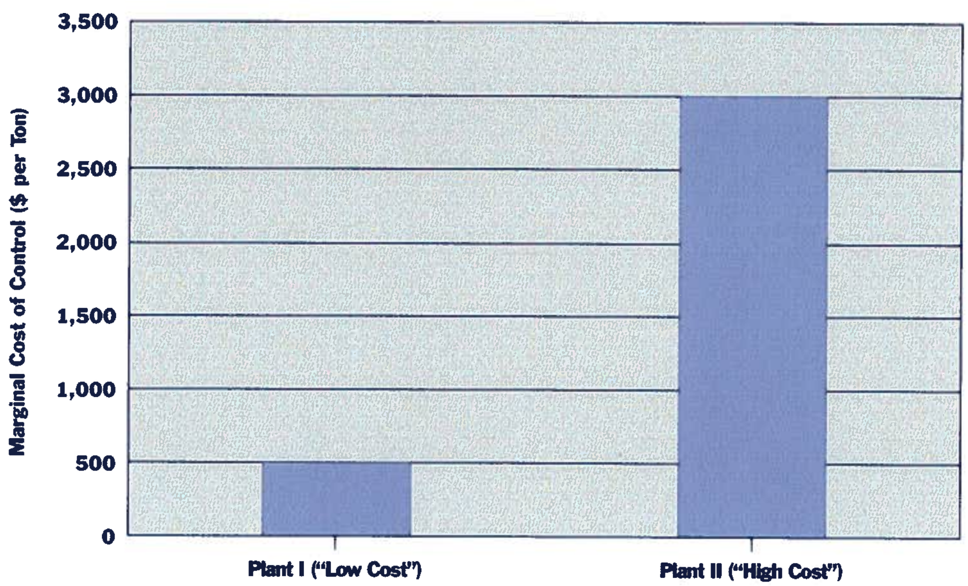
A. Overview of the Concept of Emissions Trading

The basic rationale for emissions trading is straightforward. By giving firms the flexibility to reallocate (trade) emissions credits or **allowances** among themselves, trading can reduce the compliance costs of achieving the emissions target.

A simple numerical example illustrates how emissions trading can reduce control costs relative to a traditional approach that is based upon setting uniform emissions standards (i.e., traditional command-and-control). Figure 1 illustrates a typical situation that could face facilities complying with a single uniform emission standard. In reducing emissions to meet the standard, Facility 1 incurs a cost of $500 for a ton of emissions reduced, while Facility 2 spends $3,000 for a ton reduced. These two facilities might be different plants within the same company, plants owned by different companies in the same sector, or plants in completely different sectors. The particular emissions standards that are compared to the trading approach might be based upon a common regulatory standard or on completely separate regulations.

Figure 1

Marginal Costs of Meeting a Hypothetical Standard at Two Plants



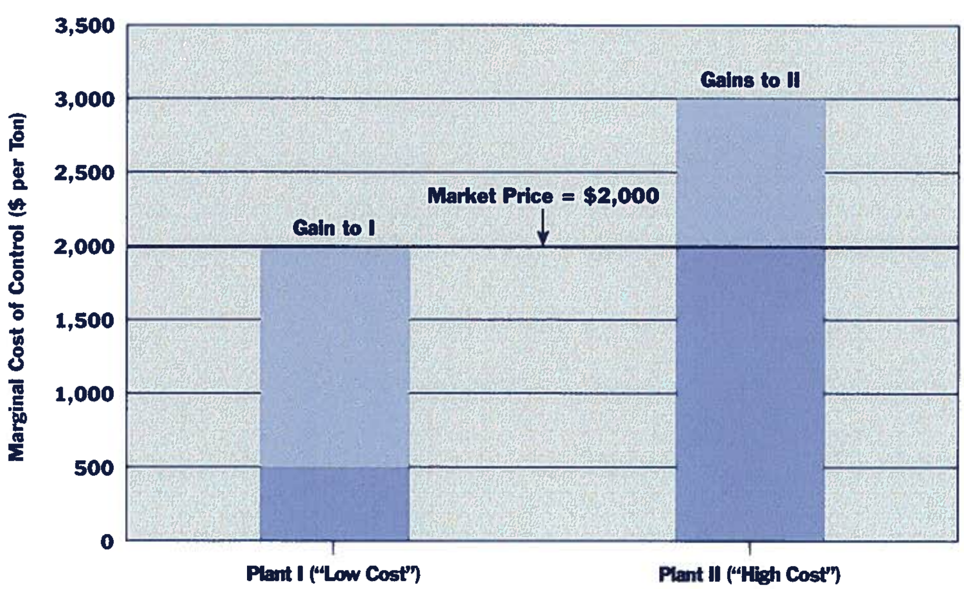
Clearly, the same overall reduction in emissions could be achieved at lower compliance costs by tightening controls at Plant I and relaxing them at Plant II. Initially, loosening controls at Plant II by one ton saves $3,000, whereas tightening controls by one ton at Plant I would raise costs by only $500, for a net savings in compliance costs of $2,500 per ton to achieve the same level of emissions. One way to achieve the cost savings would be to set different standards for the two sources, but such adjustments would be controversial (particularly if the facilities were competitors). Moreover, setting facility-specific standards would require that the government develop enormous amounts of facility-specific information to determine the cost-minimizing emissions reduction levels. These decisions are best left to the firms that operate these facilities, since they presumably have the best information about the costs of control alternatives and can use that information most effectively.

Emissions trading provides a means of achieving these cost savings without the need for regulators to collect such detailed compliance cost information for different sources. The two sources, knowing their own individual compliance costs, could trade emissions credits or allowances among themselves at the market price. Each source would compare its own emissions control costs with the market price and determine whether it is profitable to control more and sell allowances to others or to control less and buy allowances to cover the additional emissions. The trading mechanism allocates emissions reductions among sources in the most cost-effective manner, relying on individual information and self-interest—rather than administrative regulation—to determine compliance decisions by each individual source.

Suppose in the previous numerical example that the market price of an emissions credit or allowance was $2,000 per ton, and that the two facilities were **initially allocated** allowances consistent with the individual emissions levels required under the emissions standard. Figure 2 shows how each of the sources would gain from the market. Plant I (low-cost seller) gains by reducing its emissions further than the standard requires and selling the allowance it no longer needs to Plant II; it receives $2,000 for the allowance but pays only $500 to achieve the reduction, for a net gain of $1,500. On the other side of the transaction, Plant II (high-cost buyer) is able to buy the allowance for $2,000 and reduce its compliance costs by $3,000, for a net savings of $1,000. Thus the total savings in compliance costs of $2,500 per ton is split between the buyer and the seller, with both gaining from trading.

Figure 2

Gains to Plants from the Trade of a Single Emissions Allowance



This simple example illustrates both how emissions trading operates—through exchanges between buyers and sellers of the right to emit a ton—and the major cost-savings achieved. Although many details must be specified, the basic concept is the one illustrated in these two graphs.[1]

B. Three Basic Types of Emissions Trading Programs

*Three broad types of emissions trading programs have emerged: **reduction credit, averaging,** and **cap-and-trade** programs. Although all share the feature of tradability, the three differ in important respects.*

Reduction credit programs provide tradable credits to facilities that reduce emissions more than required by some pre-existing regulation (or other **baseline**) and allow those credits to be counted towards compliance by other facilities that would face high costs or other difficulties in meeting the regulatory requirements. (These programs sometimes are referred to simply as "credit-based.") Reduction credits are created through an administrative process in which the credits must be pre-certified before they can be traded.

Averaging programs also involve the offsetting of emissions from higher-emitting sources with lower emissions from other sources, so that the average emission *rate* achieves a predetermined level.[2] Like reduction credit programs, averaging programs provide flexibility to individual sources to meet emissions constraints by allowing differences from source-specific standards to be traded between sources. The primary difference between averaging and reduction credit programs is that reduction credits are created (or "certified") through an administrative process, whereas the certification is automatic in averaging programs.

Cap-and-trade programs operate on somewhat different principles. Under a cap-and-trade program, an aggregate cap on emissions is set that defines the total number of emissions "allowances," each of which provides its holder with the right to emit a unit (typically a ton) of emissions. The **permits** are initially allocated in some way, typically among existing sources. Each source covered by the program must hold permits to cover its emissions, with sources free to buy and sell permits from each other. In contrast to reduction credit programs—but similar to averaging programs—cap-and-trade programs do not require pre-certification of allowances; the allowances are certified when they are distributed initially. Also, cap-and-trade programs limit *total* emissions, a contrast to reduction credit and averaging programs that are not designed to cap emissions.

A trading program might include more than one type of trading mechanism. As discussed below, both the Acid Rain trading program and RECLAIM include reduction credit supplements to the basic cap-and-trade program. In addition, a cap-and-trade program might provide for **early reduction credits,** which allow firms to get credits for voluntarily reducing emissions prior to the introduction of a cap-and-trade program. The credits allocated can be used to meet requirements once the cap-and-trade program goes into force.

All three types of emissions trading rely on certain factors that constitute preconditions for a successful program. First and most importantly, all three forms assume that an emissions control requirement has been put in place that requires emissions to be reduced to levels below what they otherwise would be. For credit and averaging programs, the requirement will typically be a source-specific standard (e.g., a maximum emissions rate). In a cap-and-trade program the requirement will take the form of an aggregate cap on emissions combined with the provision that each source surrender allowances equal to its emissions. Second, the cost savings achieved by all three forms of trading depend upon variability in the costs of reducing emissions among emissions sources. Differences in emission control costs across emissions sources create the opportunity to reduce costs through trading. Finally, in all three types of trading programs, the requirements must be both enforceable and enforced. A corollary to this precondition is that there must be accurate measurement of actual emissions or emissions rates—otherwise it would be impossible to enforce the requirements because it would be impossible to determine whether sources were in compliance.

C. Other Features of Emissions Trading Programs

There are many features that must be specified in an emissions trading program, some of which do not apply to all of the three basic emissions trading types. The following is a list (derived from Harrison 1999a) that categorizes the major features of emissions trading programs into two major categories: design issues and implementation issues.

Design Issues. These include the decisions that arise as the program is designed and turned into a specific regulatory program.

Allocation of initial allowances. This issue is only relevant in cap-and-trade programs. Some method is required to distribute the initial allowances. Basic methods include various formulas to distribute initial allowances to participants on the basis of historical information ("**grandfathering**") or on the basis of updated information ("**updating**") as well as auctioning of the initial allowances.

Geographic or temporal flexibility or restrictions. This includes the possibility of restricting trades among different parts of the geographic range of the program (Tietenberg 1995). It also includes the possibility of **banking** (i.e., reducing emissions more than required in a given year and "banking" the surplus for future internal use or sale) or **borrowing** (i.e., reducing less than required in a given year and thus "borrowing," with the borrowed amount made up by reducing more than required in subsequent years).

Emission sources that are required or allowed to participate. This includes specification of the universe of sources that must participate in the trading program. It also includes the possibility of allowing additional sources to **opt-in** to the program.

Institutions established to facilitate trading. This includes the possibility of encouraging third parties (e.g., brokers) to participate in trading as well as the possibility of setting up an ongoing auction or other institutions to increase liquidity and establish market prices.

Implementation Issues. A number of decisions come into play as the program is implemented.

Certification of permits. This decision applies to reduction credit programs, which require that emission reductions be certified before they can be traded.

Monitoring and reporting of emissions. Methods must be designed to monitor and report emissions from each participating source (Tietenberg 2002).

Determining compliance and enforcing the trading program. These decisions relate to the means of determining whether sources are in compliance and enforcing the program if sources are out of compliance.

Maintaining and encouraging participation. This relates to decisions made to keep sources in the program and encourage participation of sources whose participation is optional (e.g., those given the opportunity to opt-in).

D. Objective and Organization of this Report

The principal objective of this paper is to draw upon the more than two decades of experience with emissions trading in the United States to provide lessons for future applications, including for climate change. The paper focuses on major U.S. domestic emissions trading programs—as they have actually been developed and implemented—and thus does not consider either the issues of setting up international trading programs or the lessons from nascent GHG emissions trading programs.[3] Because climate change is clearly a global issue, however, it is important to consider international dimensions in the design of domestic programs.

Table 1 summarizes the six major programs considered in this paper.[4] The six programs—which represent the bulk of existing experience with emissions trading—include examples of all three basic types. The U.S. EPA has administered most of the programs, although the programs include those administered by states and local air quality agencies as well. The range of experiences represented in these programs, which span about a quarter of a century, provide important insights into the factors that affect the economic and environmental performance of emissions trading in practice.

Table 1

Summary of **Emissions Trading Programs**

Program	Agency	Type	Emissions	Source	Scope	Year
EPA Emissions Trading Program	U.S. EPA	Reduction Credit, Averaging	Various	Stationary	U.S.	1979–Present
Lead-in-Gasoline	U.S. EPA	Averaging	Lead	Gasoline	U.S.	1982–87
Acid Rain Trading	U.S. EPA	Cap-and-Trade, Reduction Credit	SO_2	Electricity Generation	U.S.	1995–Present
RECLAIM	South Coast Air Quality Management District	Cap-and-Trade	NO_X, SO_2	Stationary	Los Angeles Basin	1994–Present
Averaging, Banking, and Trading (ABT)	U.S. EPA	Averaging	Various	Mobile	U.S.	1991–Present
Northeast NO_X Budget Trading	U.S. EPA, 12 states, and D.C.	Cap-and-Trade	NO_X	Stationary	Northeastern U.S.	1999–Present

The paper is organized as follows. Section II discusses experience with the principal emissions trading programs over the last quarter century, focusing on the experiences of the programs that provide significant lessons for future applications. Section III analyzes in detail the general lessons to be learned from these domestic emissions trading programs.[5] Section IV discusses special considerations that are relevant to the use of emissions trading to control GHG emissions. Section V provides concluding remarks.

II. Experience with Emissions Trading

This chapter introduces the major U.S. emissions trading programs implemented over the last two decades and the primary lessons to be learned from them.[6]

A. EPA Emissions Trading Programs (EPA ET)

Starting in the mid-1970s, the U.S. EPA and the states developed four limited emissions trading programs to increase flexibility and reduce the costs of compliance with air emissions standards for stationary sources under the Clean Air Act.

1. Netting. Netting allows large new sources and major modifications of existing sources to be exempted from otherwise applicable review procedures if existing emissions elsewhere in the same facility are reduced by a sufficient amount.

2. Offsets. The offset policy allows a major new source to locate in an area that does not attain a given **National Ambient Air Quality Standard**—a non-attainment area—if emissions from an existing source are reduced by at least as much as the new source would contribute (after installation of stringent controls).

3. Bubble. The bubble policy allows a firm to combine the limits for several different sources into one combined limit and to determine compliance based on that aggregate limit instead of from each source individually. The name alludes to an imaginary "bubble" placed over the several sources.

4. Banking. Under banking, firms that take actions to reduce emissions below the relevant standard can accumulate credits for future internal use or sale.

These four programs—collectively referred to as EPA Emissions Trading or EPA ET[7]—are related by the common objective of providing sources with flexibility to comply with traditional source-specific command-and-control standards while maintaining environmental objectives focused primarily on local air quality.

Reliance on these early EPA ET programs has been limited mostly as a result of implementing burdensome regulations that take up 47 pages of multi-column fine print in the *Federal Register*

(51 Federal Register 43814, September 1986). In general, the regulations have restricted substantially the applicability of the programs in response to regulatory concerns that the programs would compromise environmental objectives by encouraging "paper credits" or "anyway tons"—credits for emissions reductions that would have been made without the incentives provided by the emissions trading program. Credits must meet detailed criteria to be certified as eligible for trading. Offsets can only be used in certain geographic areas and any "trades" using them are not one-for-one, since the regulations require emissions reductions at the source providing the credit to be greater than the expected increase in emissions by the source using the credit. Potential applications of the bubble policy initially faced even greater hurdles because proposed bubbles had to be approved as revisions to an applicable State Implementation Plan (SIP), a lengthy administrative process that discouraged their use (U.S. Environmental Protection Agency 2001). These and other EPA regulations made efforts to identify and create trading opportunities expensive and uncertain.

The result of this process for creating and approving tradable credits, often called certification, is that the EPA ET programs have yielded relatively few trades and low cost savings relative to their potential (Hahn and Hester 1989). The combination of pre-approval requirements and the need to construct customized arrangements for each trade has created substantial transactions costs—often exceeding the market value of the credits.[8] These transaction costs—in effect the result of the lack of a well-defined and standardized commodity to be traded—have been the primary obstacle to more widespread participation in these programs.

The EPA ET programs constitute the first official recognition of the potential value of emissions trading, but the disappointing experience with these programs is the primary reason for the early reputation of emissions trading as a theoretically desirable but largely impractical concept.

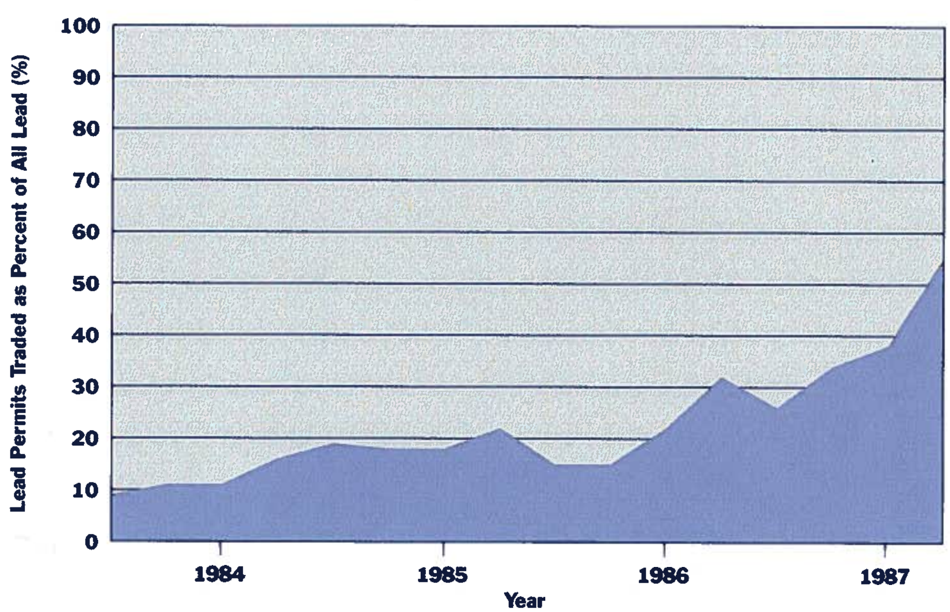
B. Lead-in-Gasoline Program

The averaging program used to regulate lead in gasoline during the mid-1980s provides an example of a much more successful trading program than the early EPA ET programs. The averaging program for lead grew out of EPA's efforts to reduce the lead content of gasoline starting in the early 1970s. Through 1982, lead limits were enforced on a refinery-by-refinery basis, with each refinery allowed to average lead concentration across its total gasoline production. In 1982, the rules were changed to allow trading across refineries and refining firms (47 Federal Register 49322). Under the new rules, a refinery could use lead in its gasoline above its usual limit if it purchased an equivalent number of rights from other refineries that had reduced their own lead content below their usual limits. It was possible to implement nationwide trading because the wide geographic distribution of gasoline from any given refinery removed the local concerns that had limited the scope of trading in the early EPA ET programs. In 1985, EPA promulgated a new rule to reduce the lead limit more than ten-fold in two phases: in mid-1985, from 1.1 grams per leaded gallon (gplg) to 0.5 gplg, and then, in January 1986, to 0.1 gplg (50 Federal Register 9400).[9] As part of this new phase-down rule, EPA allowed refiners to "bank" lead reductions: if they reduced ahead of schedule during 1985, they could save the excess rights for use or sale in 1986 and 1987.

The 1980s lead program is widely regarded as a success with respect to the initial trading opportunities permitted in the 1983–85 period and the addition of banking in the 1985–87 period. Figure 3 shows the development of the trading market for lead in gasoline. From mid-1983 (when the new rules took effect) until early 1985 (when the further phase-down began), an increasingly vigorous market in lead rights developed. In a typical quarter, over half of all refineries participated in the market, and up to one-fifth of the lead rights were traded. In 1985, when provisions for banking were added and the restrictions were tightened, an even larger fraction of lead was bought and sold on the market.

Figure 3

Lead Permits Traded as Percent of All Lead Emissions, 1983–1987



Source: Adapted from Hahn & Hester (1989, p. 387).

The banking components of the Lead Trading Program appear to have been particularly successful. The EPA had predicted that refiners would bank seven to nine thousand tons of lead, resulting in savings of up to $226 million (in 1985 dollars, discounted at a 10 percent real rate) over two and one-half years, or about 20 percent of the estimated cost of the rule over that period. Although no new estimates of the cost savings were made after banking occurred, the level of banking was even higher than predicted: refineries banked a total of 10.6 thousand tons, almost 17 percent higher than the upper end of the predicted range. Thus, it seems likely that the actual savings were higher than the EPA estimate. In addition, the use of banking led to a faster reduction in lead emissions than might otherwise have occurred.

The Lead Trading Program also marked an innovation in regulation by using the refinery-specific limit as the baseline for establishing credits without worrying about whether the lead content of gasoline from a specific refinery might have been lower anyway. This innovation avoided the need for case-by-case review to certify tradable credits. Differences between the refinery-specific average limits and the refinery's average lead content—and thus credits and debits—could be calculated easily. Monitoring for purposes of calculating credits and debits involved no additional costs beyond those required to enforce command-and-control requirements. This streamlining of the process for measuring compliance and certifying tradable credits has characterized all of the successful trading programs. In effect, the owners of refineries that reduced lead content below the average were automatically issued credits that could be used at other facilities.

Two additional conclusions may be drawn from the Lead Trading Program. First, the Lead Trading Program led to more efficient adoption of lead-reducing technologies by refiners (Kerr and Newell forthcoming). Second, banking introduced useful flexibility into the rapid phase-down in lead content scheduled for the last half of 1985. Refiners that reduced lead content ahead of schedule at one facility were able to receive automatic credit for use at other facilities, which could thereby undertake a slightly later phase-down. This flexibility reduced the costs and increased the speed with which the phase-out of lead in gasoline was achieved (U.S. Environmental Protection Agency 2001).

C. Acid Rain Trading Program

The largest, best-known, and most successful experience with emissions trading is the sulfur dioxide (SO_2) cap-and-trade program created by Title IV of the 1990 Clean Air Act Amendments. We will refer to this program as the Acid Rain Program. Two components of this program will be discussed in this report: the mandatory two-phase SO_2 cap with trading and banking that constitutes the core of the program, and the SO_2 opt-in provisions.[10]

Because of its large scale and high profile, the success of the Acid Rain Program has contributed more than anything else to the change in attitude towards emissions trading in the 1990s, and it is often cited as an example for other applications, including GHG emission reductions.

1. SO_2 Cap-and-Trade Provisions

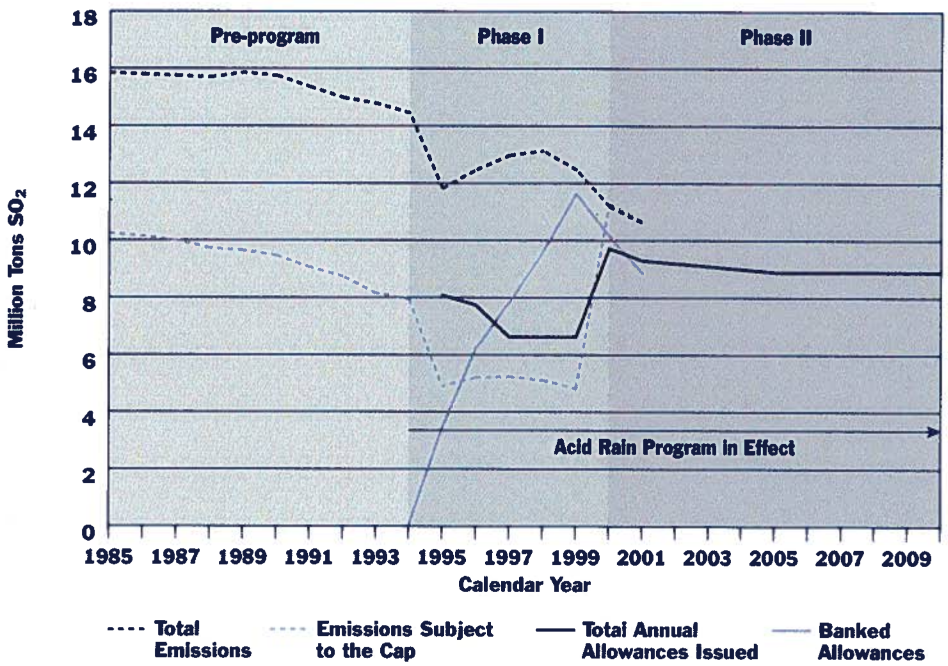
The Acid Rain Program created a national cap of roughly nine million tons of SO_2 emissions per year from electricity generating plants. The national target was to be achieved in two phases. During Phase I, lasting from 1995 through 1999, the 263 electricity generating units emitting the largest volume of SO_2 were subject to an interim cap that required projected average emissions from these units to be no greater than approximately 2.5 pounds of SO_2 per million Btu of **heat input.** In Phase II, beginning in 2000 and continuing indefinitely, the program was expanded to include virtually all fossil-fueled electricity generating facilities and to limit emissions from these facilities to a cap of approximately nine million tons—which implies an average emission rate of less than 1.2 pounds of SO_2 per million Btu. The final Phase II cap will eventually reduce total SO_2 emission from electricity generating units to about half of what they had been in the early 1980s.

This cap on national SO_2 emissions was implemented by issuing tradable allowances—representing the right to emit one ton of SO_2 emissions—equal to the total annual allowed emissions, and by requiring that the owners of all fossil fuel-fired electricity generating units surrender an allowance for every ton of SO_2 emissions. Allowances not used in the year for which they are allocated can be banked for future use or sale. These allowances are allocated to owners of affected units free of charge, generally in proportion to each unit's average annual heat input during the three-year baseline period, 1985–87. A small percentage (2.8 percent) of the allowances allocated to affected units are withheld for distribution through an annual auction conducted by the EPA to encourage trading and to ensure the availability of allowances for new generating units. The revenues from this auction are returned on a *pro rata* basis to the owners of the existing units from whose allocations the allowances are withheld.

Figure 4 illustrates the basic structure of the SO_2 cap-and-trade program and its performance. The figure portrays the two-phase structure of the SO_2 cap and its effects on emissions—both the subset of emissions from units affected in Phase I and total emissions from all units subsequently included in the program. It also shows the accumulation of the allowance bank in Phase I and the first two years of its draw down in Phase II.

Figure 4

Emissions, Allowances, and Banking Under the Acid Rain Program



Sources: U.S. EPA, 1995-2001; Pechan and Associates 1995; separation of Phase I unit emissions done by authors.

The solid dark blue line beginning in 1995 indicates the total number of allowances issued to generating units subject to the Acid Rain Program. The total is less during 1995–99 because only a subset of units, accounting for slightly more than half of national emissions, were affected during the transitional Phase I. The purple broken line plots emissions from the units subject to Title IV during Phase I from 1995 through 1999 and from all units for 2000 and 2001. The dark blue dotted line at the top indicates total emissions from *all* units, whether subject to Title IV in Phase I or not, from 1985 through 2000. The purple solid line represents the accumulated bank of unused allowances.

Since all units are subject to Title IV after 2000, the dark blue broken line and the purple broken line merge in this year. Eventually, this merged line representing total emissions will become equal with the solid dark blue line representing the cap, as the allowance bank—represented by the purple solid line—is drawn down. As the figure shows, this process began in 2000; until 2000, the number of banked allowances grew each year, but then began to be drawn down after the start of Phase II.

The most remarkable feature of Figure 4 is the striking reduction of SO_2 emissions in the first year of the program. Emissions had been falling steadily throughout the 1980s, even before Title IV was enacted, and they continued to fall at about the same rate during the first half of the 1990s.[11] But the reduction from 1994 to 1995 was far greater than anything that had been seen before, and there can be no doubt that it was caused by Title IV. The only precedent for such a rapid reduction in emissions of this magnitude in the history of the Clean Air Act is the lead phase-down program, which was also implemented by the use of emissions trading and banking.

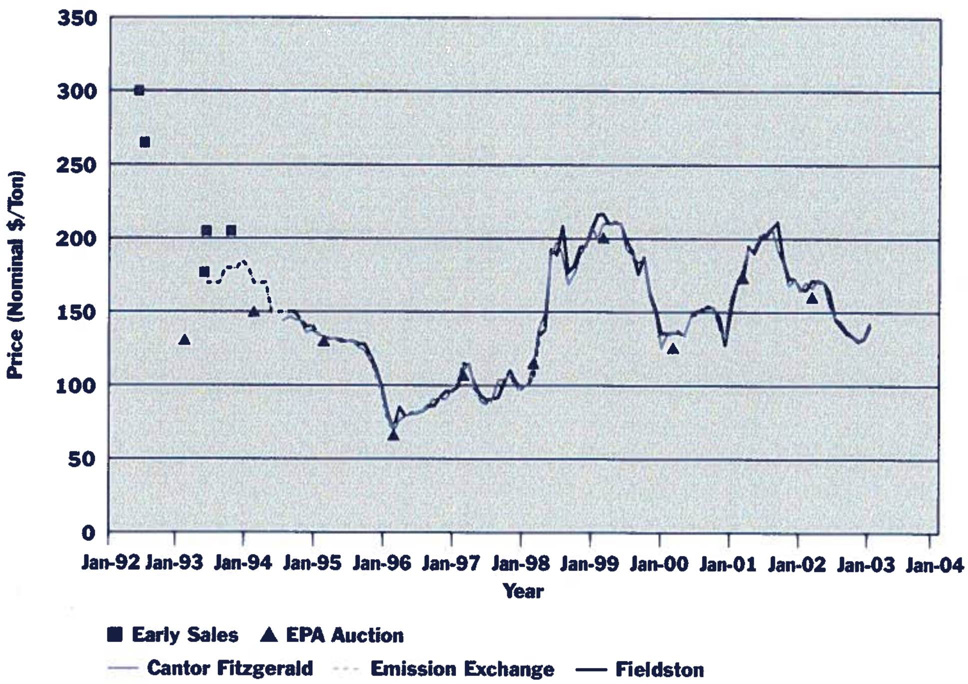
The reason for the remarkable reduction in emissions in 1995, when the allowable emissions for that year required only a small reduction in emissions, is the availability of "inter-temporal trading" in the form of banking. The prospect of higher marginal abatement costs after 2000 made abating more than required in Phase I an appealing option for smoothing the transition to the more demanding Phase II cap. As a result, the reduction in emissions experienced in Phase I was about twice what would have been required to bring emissions below the level allowed in these years.[12]

Inter-source or "spatial" trading also has been an important feature of the Acid Rain Program. Compliance data for each year shows that about one-third of the affected units in Phase I obtained allowances from other units, either by intra-firm transfers or through purchase in the allowance market, to cover emissions in excess of the allowances allocated to those units.[13] Spatial trading has allowed sources with high abatement costs to reduce emissions less—and those with low abatement costs to reduce emissions more—than under a command-and-control mechanism requiring uniform emissions rates, and thus has reduced the overall cost of the mandated emissions reduction.

The purchase and sale of allowances by the owners of affected units has created an active and efficient market for SO_2 allowances. This is evidenced by the single price for allowances at any one point in time regardless of the source of the price quote, by the high volume of inter-firm trades that can be deduced from the allowance registry maintained by EPA, by the low transactions costs associated with trading,[14] and by the development of an active and diverse contract and futures market. The EPA auction has also provided a transparent mechanism to reveal prices, which was very important in the early years when few private transactions were being reported. Figure 5 shows SO_2 allowance prices under the Acid Rain Program, beginning with early sales in 1992.

Figure 5

SO2 Allowance Prices 1993-2003



Source: Data compiled by authors from EPA auction results, periodic broker reports, and news items.

The cost savings due to emissions trading in the Acid Rain Program clearly are substantial. Table 2 summarizes estimates of cost savings developed by Ellerman et al. (2000) attributable to different types of trading, i.e., the savings due to spatial trading in Phase I, banking between Phases I and II, and spatial trading in the more stringent and comprehensive Phase II.[15]

Table 2

Abatement Cost and Cost Savings from Title IV Emissions Trading

	Abatement Cost With Trading	Abatement Cost Without Trading	Cost Savings from Emissions Trading				
			Phase I Spatial Trading	Banking	Phase II Spatial Trading	Total Cost Savings	Savings as a Percentage of Cost Without Trading
Average Phase I Year (1995–99)	735	1,093	358			358	33%
Average Phase II Year (2000–07)	1,400	3,682		167	2,115	2,282	62%
13-Year Sum	14,875	34,925	1,792	1,339	16,919	20,050	57%

Source: Adapted from Ellerman et al. (2000).

Note: All costs are in millions of present-value U.S. 1995 dollars. Estimates are based on economic reasoning assuming reasonably efficient markets based on observed allowance prices and abatement (as explained in chapter 10 of the source). A cost estimate is provided for only the first eight years of Phase II since this is the time period when most of the cost savings from banking were thought likely to be realized.

On average, spatial trading during Phase I reduced annual compliance costs by $358 million per year, a reduction of about 33 percent from the estimated cost of $1,093 million per year under a non-trading regime in which each affected unit limits emissions to the number of allowances received without any trading. During the first eight years of Phase II, the combination of spatial trading and banking is estimated to reduce annual compliance costs by about $2.3 billion per year, a reduction of over 60 percent from a total of about $3.7 billion per year. Over the first 13 years of the program, the ability to trade allowances nationwide across affected units and through time is estimated to reduce compliance costs by a total of $20 billion, a cost reduction of about 57 percent from the assumed command-and-control alternative. This percentage cost saving is similar to that developed by other researchers,[16] although it is less than the percentage cost savings sometimes claimed for emissions trading programs, including the Title IV SO_2 cap-and-trade program.[17]

There are several reasons why the Acid Rain Program has been successful. Of critical importance is the absence of any requirement for regulatory pre-approval of individual trades. Like the Lead Trading Program, the SO_2 program dispensed with the restrictions and cumbersome bureaucracy that characterized the EPA ET program. The lead program took the first step in avoiding the costly process of verifying credits for every transaction by allowing for an automatic crediting of differences from an agreed-upon baseline. Title IV took the further steps of explicitly recognizing the right to emit[18] (albeit at a reduced quantity) and then determining compliance based on an account of *all* emissions, not just the differences from the agreed-upon baseline. These further steps changed the nature of the item traded from an emission reduction, which depends on an agreed upon and non-observable baseline, to emissions that are actually measured—in this case using a **continuous emissions monitoring system** (CEMS). As was also the case in the Lead Trading Program, the reduced importance of location and timing of emissions facilitated the simpler procedures that made emissions trading successful. In both cases, the reduction in aggregate, cumulative emissions was more important than the precise pattern of reductions at individual sources. Both programs also built in flexibility in the timing of emissions reductions by allowing for banking.

The requirement to verify actual SO_2 emissions using CEMS played an important role in gaining support for the trading program and in its ultimate success. Any trading program must have an accurate method for measuring emissions so that the requirement that all emissions be matched by surrendering an equal number of allowances can be enforced. The only significant issue concerning CEMS was whether less costly alternatives would have provided equivalent measurement accuracy. CEMS added about seven percent to total Phase I compliance costs, and a less costly "materials balance" method could provide equally accurate estimates of total emissions.[19] However, environmental groups doubted the accuracy of the latter method, and negotiations and disputes with regulators over its application might well have increased transactions costs or undermined the credibility of the program (Ellerman et al. 2000).

The explicit "free" grant of allowances to the owners of affected units in the SO_2 program was another innovation in emissions trading. Since allowances have value that can be readily realized by trading, the grant of these allowances endowed the recipients with a lump-sum transfer payment. Because the allowances were granted rather than sold, and were based upon historical data rather than contemporaneous or future data, the allowances are said to be grandfathered.[20] When Title IV was enacted, this initial allocation of allowances through grants based on historical activity was not especially controversial. Since then, the method for allocating allowances for new cap-and-trade programs, especially whether the initial allocation should be through grants or auctions, has become more controversial. The issue of how to distribute the allowances created by a cap-and-trade program has inspired a rich literature exploring the welfare, efficiency, and equity implications of various methods of granting or auctioning the allowances, and, in the case of auctions, of how revenues are recycled.[21]

From the perspective of the performance of the program, i.e., the cost of reducing emissions and the speed with which they were reduced, there is no credible evidence that the initial allocations had any significant effects. This is the case because the allocation process was structured so that the number of allowances a source received was independent of its future output and its future emissions.[22] Any lump sum allocation process will not distort future output and emissions decisions and will not inhibit the performance of the program. Of course, since allowances were potentially valuable assets there was substantial political maneuvering regarding how the lump sum distributions would be made (Joskow and Schmalensee 1998). It is difficult to tell how the distribution of the valuable allowances among units compares to the distribution of the costs among units subject to the cap.

Notwithstanding its success, the SO_2 cap-and-trade program was not perfect, and it is unlikely that the full potential cost savings of an ideal "textbook" program design have been realized in practice (Carlson et al. 2000). It took time for the allowance markets to develop and mature. The fact that initially the emissions sources were primarily regulated utilities may have reduced incentives to trade and slowed the development of efficient markets. Phasing in sources subject to the program complicated the program's administration and also lessened the achievement of the emissions reduction goals (McLean 1997).[23] In particular, some misuse occurred as a result of the opt-in features of the program, which is discussed in the next section. Despite these caveats, it seems safe to conclude that the major economic and environmental promises of the SO_2 cap-and-trade program have been realized.

2. Opt-in Features of the SO_2 Trading Program

The opt-in features of the SO_2 cap-and-trade program demonstrate two major points: (1) participation in opt-in programs can be considerable; and (2) these opt-in programs can detract from the achievement of the program's environmental goals. The Acid Rain Program had two principal **voluntary** features.[24] One opt-in component allowed generating units not subject to Title IV until Phase II to receive allowances and to be subject to emission coverage requirements in Phase I. A second opt-in component allowed industrial sources of SO_2 emissions not otherwise subject to Title IV to receive allowances and to be subject to emission coverage requirements in Phase I or II. The provisions applying to electricity generating units were extensively used, with approximately 30 percent of eligible sources participating;[25] but the industrial opt-in provisions were little utilized. The experience with these two opt-in programs says much about the motivations behind voluntary participation and the problems that it may create.

The high participation rate in the opt-in program by electric utilities was encouraged by several factors. First, virtually all of the Phase II units eligible for opting-in were owned by utilities that were already incurring the overhead costs of dealing with the Acid Rain Program's requirements because they owned units required to be a part of Phase I. Second, the transaction costs of monitoring and reporting emissions were already being incurred because electric utilities were required to install CEMS on all units subject to the Acid Rain Program and to report emissions from those units beginning in 1995 regardless of whether the unit was required to be in Phase I or not. Finally, the owners of eligible units knew beforehand how many allowances they would receive since this had been clearly defined in earlier regulations. Unlike the EPA ET programs, the transaction costs were low for any electricity generating units eligible for opt-in participation in the Acid Rain Program. This made the theoretical flexibility provided by the opt-in provisions a realistic option to allow affected sources to reduce the costs of complying with the emissions caps.

In contrast, industrial facilities that might opt-in would need to establish an inventory and baseline and incur the costs of monitoring emissions and participating in the program. As Atkeson (1997) points out, these transaction costs explain the absence of industrial opt-ins. The circumstances of the few that did opt-in emphasize the importance of transactions costs: all industrial opt-in facilities involved an electric utility that was already participating in the program and all facilities had either already installed CEMS equipment or would not be required to do so because the industrial source was being replaced by an electric utility unit.

The ease with which Phase II units could choose to opt-in to Phase I was not without some potential environmental costs. In principle, units opting-in were to be given allowances equal to their emissions had they not opted-in. In practice, projecting hypothetical emissions was difficult because of the time that had elapsed between the determination of the baseline and the receipt of the allowances. One major problem was that trends in coal markets were causing many units to switch to lower sulfur coal anyway. Instead of only those facilities with low abatement costs choosing to opt-in, opting-in became attractive for facilities whose emissions would have fallen below the baseline levels anyway without the additional reductions required by Title IV. In such cases, the difference between the defined baselines and actual emissions created "anyway emissions reductions" and an associated incentive to opt-in to Phase I to obtain valuable allowances that would not be required to cover actual emissions.[26]

Determining baseline allowances for opt-in units was by far the most contentious issue in the implementation of Title IV. As a result of litigation, allocations to opt-in units were reduced, but this did not eliminate the baseline problem. As shown in the careful and detailed analysis conducted by Montero (1999),[27] the units most likely to volunteer were those whose expected emissions were lower than the baseline. Indeed, Montero finds that "baseline errors" were the most significant factor affecting utility decisions to opt-in under the voluntary provisions. As he points out, the problem is a classic one of asymmetric information in which the owners of the units opting-in know more about emissions trends than the regulator.

Although the increase in emissions due to the voluntary component of the program needs to be acknowledged, its magnitude in this case also should be put in perspective. Montero estimates that the effect on emissions was tiny. "Anyway emissions reductions" accounted for less than two percent of total emissions over the first ten years of Phase II, the period in which these extra allowances would be used.

A comparison of the experience with the voluntary components of the Acid Rain Program and the EPA ET programs suggests opt-in programs have both potential benefits and potential costs. Effective program design must face an unavoidable tradeoff. Simple rules and clearly specified baselines reduce certification costs greatly and thereby encourage voluntary participation and real reductions that reduce costs. But these simple rules may also result in paper credits that can detract from the achievement of the environmental goal. Paper credits can be avoided by requiring elaborate case-by-case determinations of what emissions would be; but the costs of case-by-case certification can discourage participation to such an extent that no cost savings are achieved. Accordingly, the design of opt-in programs should be sensitive to both the potential cost savings and the potential for adverse selection and should carefully consider the likely costs and benefits in specific cases.

D. Los Angeles Air Basin RECLAIM Program

Regulators in the Los Angeles air basin were developing another prominent cap-and-trade program in the early 1990s at the same time that the Acid Rain Program was being developed. This program, called the Regional Clean Air Incentives Market (RECLAIM), was significant both in some of its provisions and as the first major example of a tradable permit program developed by a local jurisdiction rather than a federal authority.

The South Coast Air Quality Management District (SCAQMD) approved the RECLAIM program in October 1993 after a three-year development process, and the program began operation in January 1994 (South Coast Air Quality Management District 1993). RECLAIM was developed as an alternative means of achieving the emission reductions of NO_X and SO_2 mandated by a set of command-and-control measures in the 1991 Air Quality Management Plan to bring the Los Angeles Basin into compliance with National Ambient Air Quality Standards. Under RECLAIM, the caps for both NO_X and SO_2 were set higher than expected emissions in the initial years, but the overall caps were reduced steadily over time so that, by 2003, emissions from sources emitting more than four tons of either pollutant would be reduced to about 50 percent below early-1990s emission levels. From 2003 on, the caps would remain constant.

Several features of the design of the RECLAIM program distinguish it from the Acid Rain and Lead Trading Programs. First, a heterogeneous group of participants is covered by the program, including power plants, refineries, cement factories, and other industrial sources. Second, the RECLAIM program distinguishes between emissions in two geographic zones.[28] Since emissions in the Los Angeles Basin generally drift inland from the coast, sources located in the inland zone were allowed to use RECLAIM Trading Credits (RTCs) issued for facilities in either the inland or coastal zones, but sources located in the coastal zone could use only RTCs issued for facilities in the coastal zone. A third distinctive feature of the RECLAIM program is that it does not allow banking because of concerns that the ability to use banked emissions might lead to substantial increases in actual emissions in some future year, and thus delay compliance with ambient air quality standards. RECLAIM does provide limited temporal flexibility, however, by grouping sources into two 12-month reporting periods, one from January through December and the other from July through June, and by allowing trading between sources in overlapping periods.

The initial allocation of RTCs was the most contentious part of the planning process, although eventually an allocation plan acceptable to the wide range of affected facilities was developed (Harrison 1999a). As was the case with the Acid Rain Program, RTCs were allocated free to incumbents and distributed many years prior to when they could be used for compliance.[29] The final set of formulas for allocating RTCs departed considerably from the simple formula initially proposed by the SCAQMD, and it was the result of literally dozens of proposals, many of which were exhaustively studied by the SCAQMD (and no doubt by the affected firms as well). Despite threats by several firms and sectors to oppose the program if their formulas were not chosen, the final result was an administratively feasible and politically viable cap-and-trade program.

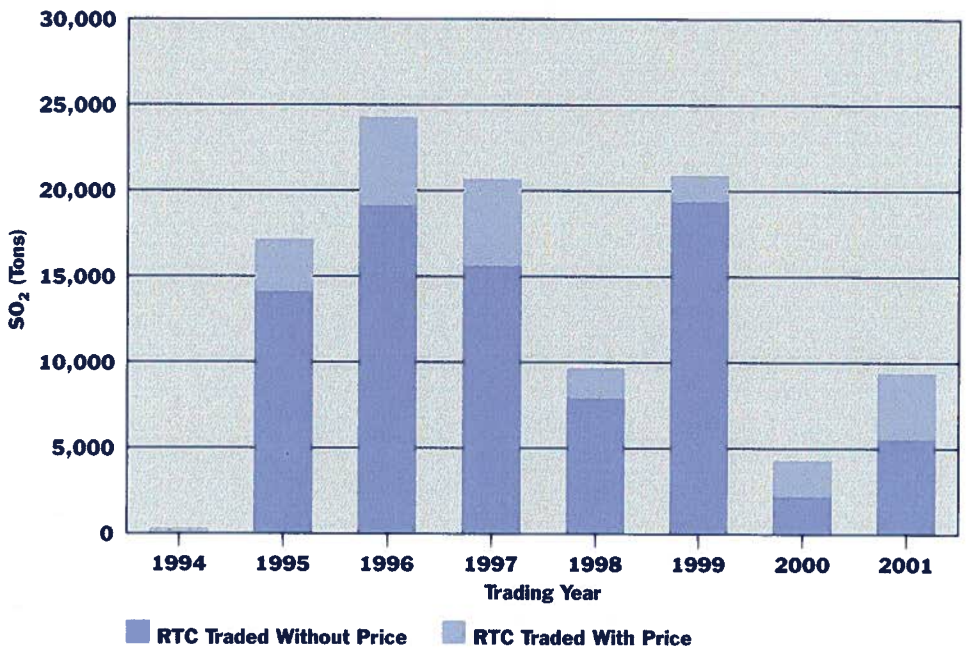
Experience in the first eight years of RECLAIM has been more mixed than in the Acid Rain and Lead Trading Programs. As with those programs, markets for the trading of credits and allowances appeared quickly and the volumes traded have been significant. However, unlike those programs, the NO_X component of the RECLAIM program has run into substantial difficulties. In late 2000 and early 2001, NO_X RTC credit prices rose to extraordinarily high levels primarily as a result of increased demand. The increase in RECLAIM NO_X prices was a significant contributing factor to the dramatic increase in California wholesale electricity spot market prices during 2000 (Joskow 2001; Joskow and Kahn 2002). As a result of these circumstances, NO_X emissions exceeded the cap for 2000 by about six percent. These events provoked major changes to RECLAIM that have in effect suspended participation by electricity generators and returned the control of emissions at least temporarily to a command-and-control program. Since difficulties and not only successes generate lessons, as seen with the opt-in aspects of the Acid Rain Program, we make a considerable effort to explain these developments in the RECLAIM NO_X program. First, however, we turn to the trading experience with both NO_X and SO_2 RTCs prior to and during California's electricity crisis in 2000–01.

Figure 6 and Figure 7 show the volume of trading in SO_2 and NO_X RTCs over the first eight years of RECLAIM. The figures show the number of RTCs of all **vintages** "traded" internally among different sources owned by the same firm (i.e., without a price), as well as the number of RTCs traded between firms at various prices. As of the end of 2001, RTC permits for over 300,000 tons of NO_X and over

100,000 tons of SO_2 had been traded. Since the aggregate NO_X and SO_2 caps were non-binding in the first few years of the program, and because the volumes traded in virtually every year exceed that year's cap (often by several multiples), the presumption is that most of these trades are in future vintages.[30] Moreover, the trend of decreased trading over time, especially for NO_X, suggests that future vintages were bought, sold, and transferred ahead of time, in keeping with plans to install the required abatement equipment to meet the final cap in 2003 and thereafter.

Figure 6

SO_2 Trading Volume Under RECLAIM (Including Future Vintages), 1994-2001

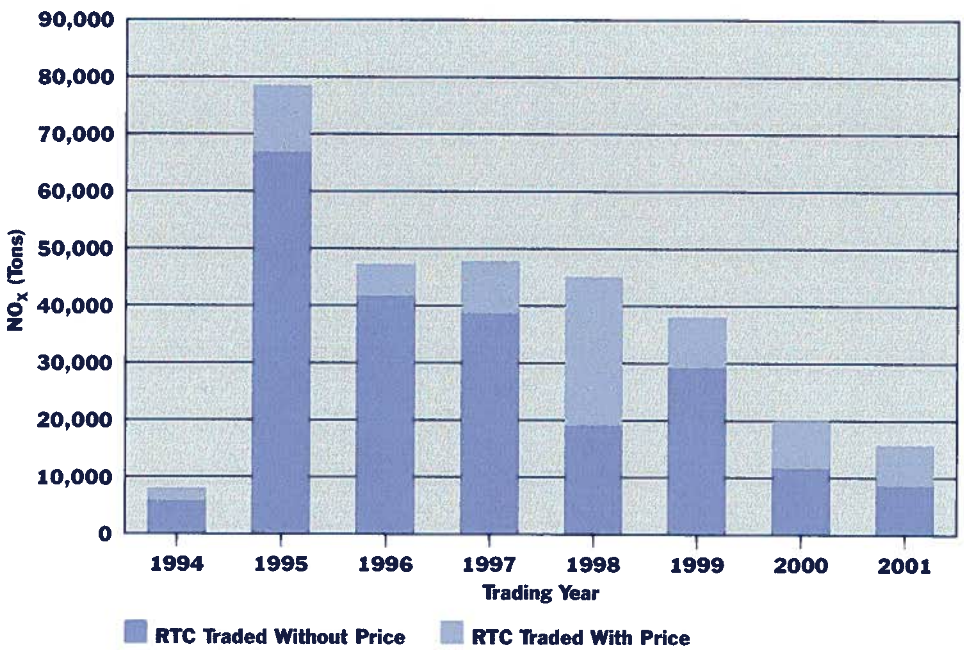


Source: South Coast Air Quality Management District (2002).

Although most of the trading has occurred within firms, the volume of external trades among firms has been significant measured against the annual volume of current or post-2003 vintages. Numerous brokers and other intermediaries have emerged to facilitate these trades and to provide other services to participants, such as pricing information and derivatives to manage price risk. Transaction costs have been relatively low and there can be no doubt that RECLAIM markets have been active. The adequacy of these markets was affirmed by the rejection of a proposal in 2002 to require the use of a centralized market for all RTC transactions. The SCAQMD ruled that there was no evidence that the existing system of bilateral transactions was not working sufficiently well to provide efficient markets for RTCs of both current and future vintages (South Coast Air Quality Management District 2002).

Figure 7

NO_X Trading Volume Under RECLAIM (Including Future Vintages), 1994-2001



Source: South Coast Air Quality Management District (2002).

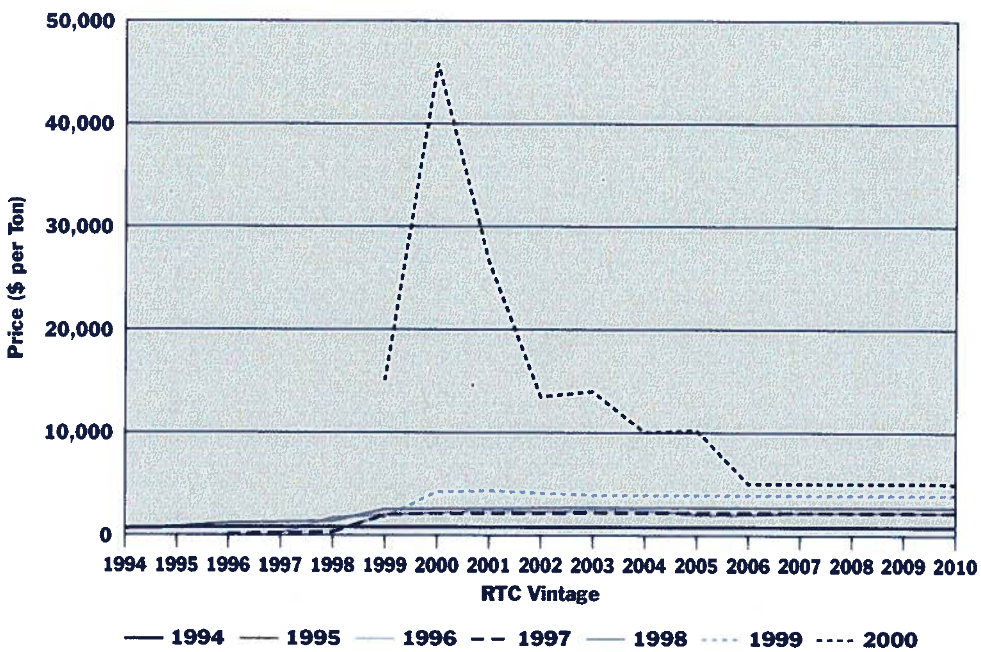
RECLAIM required that the largest sources use CEMS—like the SO_2 cap-and-trade program—to verify their emissions as a means of providing assurance that the data were valid. When the program first was implemented, there were technical difficulties with some of the CEMS and some facilities could not rely upon CEMS data for all of their submissions (South Coast Air Quality Management District 1998).[31] These difficulties prompted requests that the large sources be allowed to use the less expensive monitoring options allowed for smaller sources, a request that was denied by program administrators. Eventually the technical difficulties with these CEMS were overcome and virtually all of the emissions data from large sources now are based upon the CEMS information. As with the SO_2 program, although CEMS are expensive, their use in RECLAIM ultimately may reduce transaction costs by reducing the perceived need for the more costly review of emissions data.

The high volume of trading in the RECLAIM program implies significant cost savings relative to the command-and-control alternative that it replaced, but no *ex post* estimates of these cost savings have been made. When the program was being developed, cost savings were estimated to be about 40 percent compared to the cost of achieving the same emission levels using the traditional command-and-control approach (see Harrison and Nichols 1992 and Johnson and Pekelney 1996).

The difficulties experienced by the RECLAIM program in 2000 centered around the NO_x market, and the problem manifested itself most visibly in the dramatic spike in the price of NO_x RTCs in the year 2000 for vintages of this year and those surrounding it, as shown in Figure 8.

Figure 8

Average **NO_x RTC Prices**



Source: South Coast Air Quality Management District (2001b).

The horizontal axis in Figure 8 represents the vintage, i.e., the year in which the RTC can be used, and the lines in the graph show the average prices for current and future vintages in successive calendar years. Thus, the lines show the forward prices for the current and future vintages in each calendar year. The purple broken line representing 1999 in Figure 8, for example, indicates that the price in 1999 of the current 1999 vintage is substantially lower than the 1999 prices of future vintages (2000, 2001, 2002, etc.), which are about equal. In addition, between 1994 and 1998, the prices of all NO_x RTC vintages remained relatively stable, ranging from $1,500 to $3,000 per ton. In year 2000, the prices for all "near-term" vintages of allowances jumped significantly (the peak of the top dark blue broken line in the figure), with the largest price increase exhibited for the 2000 vintage allowances, tapering off quickly for later vintages.[32] The price for year 2000 NO_x RTCs increased from an average of $4,284 per ton for trades in 1999 to almost $45,000 per ton for trades in 2000 (comparing the "1999" line with the "2000" line). The average price of 2000 vintage NO_x RTCs reached in the peak month in 2000 was more than $70,000 per ton, with the highest single price reported equal to more than $90,000 per ton. The price increases—in 2000, relative to 1999—for 2001 and later vintage allowances (the points on the top line) were smaller and taper off for farther-out vintages.

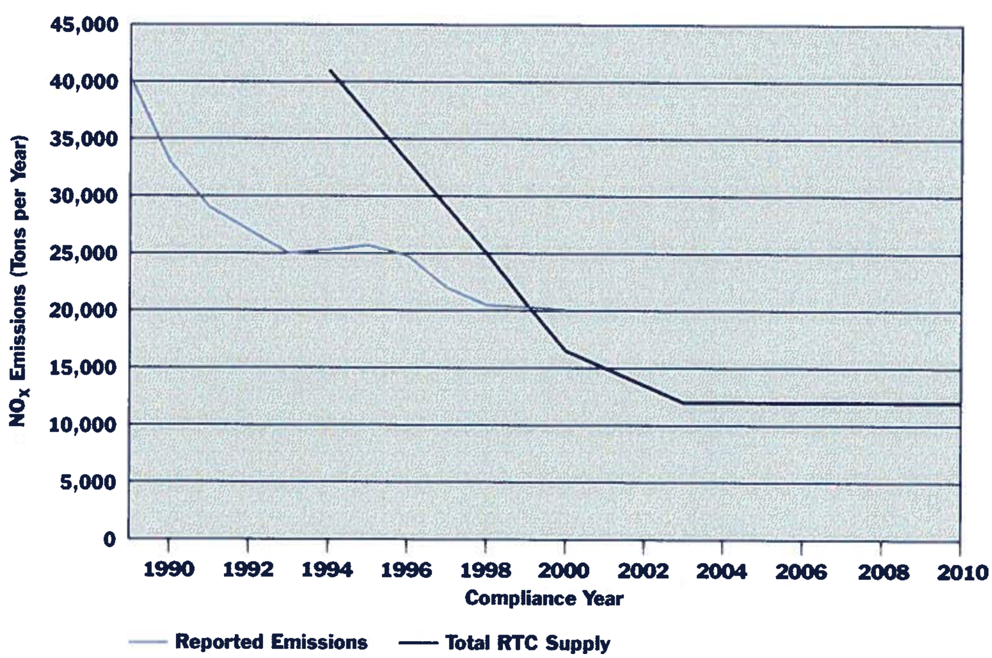
This dramatic increase in the cost of NO_x RTCs in the summer of 2000 was caused by a substantial increase in the demand for RTCs on the part of electricity generators. The demand for electricity soared in California during the summer of 2000 while the availability of imported power from other states declined (Joskow 2001). The increased demand had to be met by running the large fleet of old in-state gas-fired generating facilities more intensively than in the recent past. Few of these old plants had yet installed NO_x emissions controls and no new plants were completed until the summer of 2001. As a result, the demand for NO_x RTCs and their prices increased significantly during summer 2000 as generation from the in-state gas fired power plants increased to balance supply and demand. Indeed, as Joskow and Kahn (2002) show, the high price for NO_x RTCs was one of several factors leading to the high wholesale electricity prices in California during that period.[33]

In response to the price spikes for NO_x RTCs—along with the breach of the cap and the price spikes for electricity linked in part to high NO_x prices—electricity generating plants were removed from the RECLAIM program, at least temporarily, in May 2001 (South Coast Air Quality Management District 2001a). The electricity generators were allowed to pay a mitigation fee of $15,000 per ton when they exceeded their caps—with fee revenues used to pay for emission reductions elsewhere—and were placed temporarily under an alternative command-and-control regulatory regime. Thus, an unfortunate outgrowth of the California electricity crisis was the abandonment—at least temporarily—of the use of a successful cap-and-trade program to control electric power emissions.

What lessons can be learned from the problems that emerged in 2000 and the responses to them? With regard to lessons for the environmental performance of RECLAIM, Figure 9 shows the evolution of the annual NO_X cap from 1994 and reported NO_X emissions since 1989. The increase in demand on electric generating units in 2000 caused emissions to exceed the 2000 cap by about 3,000 tons, or 20 percent; however, the use of allowances from the overlapping 1999 and 2001 cycles reduced the shortfall between NO_X emissions and RTCs to 1,110 tons, or about six percent of the 2000 cap, a modest increase given the extraordinary circumstances in 2000. In addition, as noted, the mitigation fees paid by electricity generators are to be used to reduce emissions from other sources and, in any event, the shortfall in emissions will be reflected in decreased future NO_X RTC allocations. Thus, the net effect on NO_X emissions of the increase in demand in 2000 for NO_X allowances is largely to shift a small number of NO_X emissions reductions to future years. Moreover, there is no reason to believe that a command-and-control alternative would have performed better under the circumstances. Indeed, since command-and-control mandates typically regulate emission *rates*—rather than overall emissions—this alternative would likely have resulted in the same emissions increases but without the compensating measures taken as a result of exceeding the RECLAIM NO_X cap.

Figure 9

NO_X Emissions and Available RTCs



Source: South Coast Air Quality Management District (2002).

Perhaps the most important lesson from the 2000 experience with RECLAIM is that the "problems" were due primarily to flaws in California's newly deregulated electricity markets rather than to serious flaws in the RECLAIM program itself. The RECLAIM trading regime operated largely as it should have. Demand for NO_X RTCs increased, their supply decreased and their prices increased as expected, and the prices of an important product (electricity) that required NO_X credits also increased.[34] This should have provided signals to affected sources to invest in emissions controls, as well as signals to consumers to reduce consumption of electricity. Had the structure of California's electricity industry remained composed of regulated monopolies, or if the transition to new competitive market structures had been done more competently and with greater sensitivity to the interactions between NO_X RTC prices and spot electricity prices, the impact of higher NO_X RTC prices on the average price of electricity would have been much more modest.[35] And if the electricity crisis had not occurred, electricity generators likely would not have been removed—at least temporarily—from the NO_X RECLAIM program.

Nevertheless, the California electricity crisis should make us sensitive to the fact that in the absence of inter-temporal flexibility, short-term fluctuations in emissions levels can lead to significant volatility in allowance prices. Allowance price volatility in turn can lead to significant short-term volatility in prices of goods whose production involves significant "use" of emissions allowances. Accordingly, the recent experience with RECLAIM suggests that it is important to give emissions market participants the necessary tools to manage extreme price volatility effectively. The ability to bank allowances, a tool that was largely unavailable under RECLAIM, is one potentially important tool for managing price volatility.

E. Mobile Source Averaging, Banking, and Trading (ABT) Programs

The federal mobile source averaging, banking, and trading (ABT) programs are similar to the Lead Trading Program in providing the manufacturers of certain mobile sources of emissions the flexibility to trade, without expensive pre-approval, differences around a pre-specified emission rate standard, usually expressed as emissions per horsepower-hour. The acronym ABT refers to the specific uses for the credits, namely, (1) "averaging" emissions over engine families produced by the manufacturer in the same model year, (2) "banking" credits to offset emissions from the same or other engine families produced by the manufacturer in future years, or (3) "trading" credits by sale to another firm to offset emissions from that firm's engine families. Instead of requiring manufacturers to meet the same emission standard for all of their engine families within a particular category, such as heavy-duty trucks or lawn mowers, the ABT programs grant manufacturers credit for engine families with emissions rates *below* the emission rate standard. Credits can then be used to offset emissions from other engine families that are above the standard.

The calculation of emissions credits (and "debits") is based upon clearly established factors that differ somewhat by mobile source category. The factors typically include the difference between the applicable emissions standard and the engine family emissions limit (FEL), estimated sales of each engine in the relevant model year, estimated average annual use in hours, the power output of the engine family, and the expected useful life of each engine. The regulations frequently also allow banking of "early action" credits for emissions reduced before the program is put in place. Like the Lead Trading Program, the monitoring of emission rates required to implement ABT programs is the same as that required to implement a traditional command-and-control program. Thus, no major additional monitoring costs are imposed by ABT.

The ABT approach was first provided for heavy-duty trucks in 1991 and has been extended to several other categories of mobile sources regulated under Title II of the 1990 Clean Air Act Amendments. The mobile source categories with ABT programs now include the following:[36]

- Automobiles and light-duty trucks;[37]
- Heavy-duty truck engines;
- Large non-road diesel engines used in construction, agriculture, and other uses;
- Locomotive engines;
- Marine outboard engines and personal watercraft; and
- Small engines used in various lawn, garden, and other applications.

In addition, ABT programs have recently been initiated to cover the sulfur content in gasoline and diesel fuel, and these appear likely to become important new applications of emissions trading.

Experience with the existing ABT programs indicates that averaging and banking are much more heavily used than trading. In the case of heavy-duty trucks and buses—which have been subject to the program for the longest period—there has been considerable averaging and banking, but only one trade between firms (U.S. Environmental Protection Agency 2001).[38] Several factors may explain this pattern: (1) the small number of manufacturers and thus of potential trading partners, (2) the likelihood that the differences in abatement cost exist more among different engine families than among different manufacturers of the same engine families, (3) lower transaction costs for keeping transactions within the firm, and (4) the possibility that trading could reveal sensitive information about emissions costs to direct competitors. In any case, manufacturers have responded to the flexibility provided by ABT programs, mostly by intra-firm trading, and it is reasonable to assume that the costs of compliance with the emission rate standards have been reduced without adverse environmental impact.[39]

The ABT programs further exemplify that the flexibility provided by emissions trading reduces costs and allows more ambitious environmental targets to be adopted. In the case of marine outboard and personal watercraft engines, for example, the EPA set the average emissions standard in part on the basis of a marginal cost curve that assumed emissions trading.[40] If the ABT provisions had not been included, the average emissions standard would likely have been less stringent to accommodate the higher costs of compliance for some manufacturers and engine families, or different standards would have been established for each engine family. The cost-saving flexibility of ABT allowed the EPA to set an average for all engine families without having to deal with the problems of imposing high costs on some engine families. Since the engines in each family are distributed nationwide, there is no evidence that the deviations from the single standard have adversely affected the attainment of local environmental standards. If anything, the lower average has helped localities in non-attainment achieve ambient air quality standards.

F. Northeast NO_X Budget Trading

The Northeast NO_X Budget Trading program grew out of provisions in the Clean Air Act Amendments of 1990 that facilitated common actions among the District of Columbia and twelve states in the Northeastern United States[41] to deal with concerns about regional tropospheric ozone or "smog." These participants adopted a cap-and-trade program to reduce NO_X emissions from electricity-generating facilities having 15 MW of capacity or greater and equivalently sized industrial boilers by about 60 percent from uncontrolled levels in a first phase starting in 1999 and by up to 75 percent in a second phase starting in 2003.[42]

A unique feature of the program is that it operates only during the summer months, from May through September, when NO_X effects on ozone concentrations are greatest in this part of the country. Although the environmental objective is to reduce the incidence of ozone non-attainment, the program does not contain provisions that would distinguish days during the summer when the ozone standard is exceeded from days when it is not. Several ideas to address this problem were considered, but none were considered feasible (Farrell 2000). Instead, reliance is placed on the decrease in the overall level of NO_X emissions during the critical summer season.

The program includes a novel banking provision that attempts to address the concerns about excess concentrations that also were present in the design of the RECLAIM programs. Instead of banning banking altogether, a mechanism called Progressive Flow Control was devised that permits unused allowances to be banked but limits the use of these allowances in future periods.[43] If the total number of banked permits exercised in one year exceeds ten percent of the cap for that year, some of the banked allowances would be "discounted" by 50 percent (i.e., for each ton of NO_X emitted, *two* banked allowances would have to be redeemed). The proportion of discounted allowances grows with the size of the bank relative to the cap for that year. While this provision diminishes the incentive for sources to bank emissions, it does not seem to have discouraged banking. NO_X emissions during the summer season from affected sources in the eight participating states were approximately 175,000 tons, about 20 percent below the total number of allowances distributed (see Farrell 2000).

The Northeast NO_X Trading Program is the first major example of a multi-jurisdictional program, developed by several states, instead of being imposed by the federal government (as was the case with the Title IV SO_2 Program) or by a local regulator (as was the case with the RECLAIM program in the Los Angeles Basin). The 1990 Clean Air Act Amendments created an Ozone Transport Region containing the twelve Northeastern states, and these states and the EPA then worked together to develop a "Model Rule" as a guide to programs to be adopted by the individual states. Nine states have adopted trading programs that have generally followed the Model Rule.[44] Allowances are allocated to each state based upon 1990 emission rates, and each state then determines the allocations to individual boiler units.

The principal variations from the Model Rule have concerned allocations to individual units. Some states have adopted an "updating" approach whereby allocations are not fixed for all time based on some historic period, as in the Acid Rain and RECLAIM programs, but changed periodically as old units are shut down and new ones brought into service (Harrison and Radov 2002). For example, Massachusetts bases allocations to electricity generators on the average of the two highest electricity output years for the six, five, and four years prior to the allocation year. Updating can provide a counterproductive incentive to increase production in order to gain more allowances in the future and thereby can reduce the cost savings from trading. But this effect (and thus the inefficiency) is considerably attenuated by the effect of discounting when the lag—i.e., the time between production and receipt of more allowances—is substantial, and when emissions costs are small relative to total operating costs.

The NO_X Budget Program in the Northeast Ozone Transport Region has not been in operation long enough to evaluate its effectiveness or cost savings thoroughly, although an early review suggests the program is operating effectively (Farrell 2000). During 1999, the first year of the program's implementation, NO_X emissions from affected units decreased by 64 percent from the "uncontrolled" 1990 level of emissions and by another 25 percent from the 1998 level, which was already about half the 1990 level due to the application of NO_X RACT (Reasonably Available Control Technology) requirements. No study has been conducted on the effects of the reduction in total NO_X emissions on ozone levels (or exposure levels) in areas within the region. However, concerns about the direction of trading (purchases of allowances by upstream sources from downstream sources) in the Northeast appear not to be justified.[45]

The speed with which the NO_X market developed is also notable. Despite a slow and awkward start (Farrell 2000), about 16 percent of 1999 vintage NO_X allowances were traded among economically distinct entities and a slightly larger percentage of the 1999 allowances were reallocated among units owned by the same firm. The quick development of the NO_X market has been attributed to the participation of marketing and brokerage firms that participate in power, emissions, fuel, and other markets simultaneously, and to whom generating companies are turning for risk management services (Farrell 2000). Also, the NO_X market involved greater use of derivative products (e.g., options) than the SO_2 market, because of its greater price volatility and its later start—at the time when similar derivatives were being developed for the SO_2 market.

III. Lessons from Experience with Emissions Trading

A. Economic Effectiveness

Emissions trading has been successful in its major objective of lowering the cost of meeting emission reduction goals. The high volume of trading observed in nearly all programs provides circumstantial evidence that this objective has been achieved since there would be little reason to trade other than to reduce costs. In addition, the Acid Rain Program has been the subject of specific studies that have carefully quantified the cost savings.

The early examples of emissions trading—the EPA ET programs—produced relatively small reductions in control costs simply because few trades actually took place. The cumulative savings from the EPA ET programs totaled at most several billion dollars, a few percentage points of the hundreds of billions of dollars spent to control the stationary emission sources that could benefit, in theory, from trading. The cost savings from the Lead Trading Program were greater. As much as 50 percent of overall lead rights were traded in a given year and significant banking activity indicates additional gains.

The Acid Rain Trading program has the most solid evidence of cost savings from trading as the result of several careful studies that have attempted to assess gains from both spatial and temporal trading under the cap-and-trade component of the program (Ellerman et al. 2000; Carlson et al. 2000). These gains are measured in comparison to estimates of the costs that would have been incurred to obtain the same emission reductions without emissions trading. They confirm that cost savings can be achieved and that compliance costs have been reduced by as much as 50 percent relative to the costs of a command-and-control alternative.

None of the other emissions trading programs have been subject to careful *ex post* studies, but all have experienced significant trading activity, which suggests cost savings. In RECLAIM, trading activity has been substantial, with the overall volume in any given year exceeding the annual cap as a result of trading in future vintages. This high level of trading suggests that the estimates of cost savings of 40 percent made when RECLAIM was being designed may have been achieved, although future cost savings from RECLAIM will depend on whether electricity generators re-enter the program. Similarly, no estimates have been developed for the many mobile source ABT programs or the relatively new Northeast NO_x Budget Trading Program. Experience with the ABT programs applied to sources ranging from heavy-duty trucks to lawn mowers indicates substantial use of the averaging and banking flexibility, but virtually no use of inter-manufacturer trading. This pattern suggests both that the major cost-saving gains are realized by internal trading and that trading may be limited when participants include only a small handful of competing firms who may be reluctant to trade for fear of revealing confidential information to competitors. The Northeast NO_x Budget Program seems to be functioning well—partly due to relatively sophisticated broker activity—with about one-third of allowances being exchanged either internally or externally.

With the exception of the early EPA ET program, the emissions trading programs reviewed in this paper appear to have been successful at realizing in practice the gains from trade that have long been predicted in theory. As such, these programs provide a solid basis for expecting that future well-designed emissions trading programs will realize significant cost savings in comparison to conventional command-and-control alternatives.

B. Environmental Effectiveness

The use of emissions trading has enhanced—not compromised—the achievement of environmental goals. Emissions trading is sometimes portrayed as a way of evading environmental requirements, but the experience to date has demonstrated the opposite. Environmental goals have not been compromised by trading; rather, emissions trading has helped achieve environmental targets.

Enhanced environmental performance can be attributed to the increased flexibility associated with emissions trading for three reasons. First, where emission reduction requirements are phased in and firms can bank emission reductions—as was the case in the Lead Trading, Acid Rain, ABT, and Northeast NO_x Budget Programs—the achievement of the required emission reduction has been accelerated. The early reductions may defer the achievement of future annual emissions control targets as the banked credits are used. However, as long as a positive discount rate is assigned to the benefits associated with emission reductions—as is surely the case, since benefits today are preferred to the same benefits tomorrow—accelerating the timing of the cumulative, required emission reductions is an environmental gain.

Second, allowing firms that face high marginal costs of abatement, or even technical infeasibility, to comply with environmental requirements by buying allowances—effectively paying others to reduce more on their behalf—has eliminated one of the features of command-and-control programs that diminishes environmental effectiveness. In a command-and-control program, economic hardship or technical barriers can be dealt with only by relaxing the emissions standard in some way. While often justified, these exceptions reduce the regulation's environmental effectiveness because they are one-sided: standards are relaxed to avoid "hardships" for some facilities, but increased emissions cannot be offset by increasing standards at facilities for which abatement is less expensive or easier technologically. The net result is more emissions than would be produced by an "ideal" regulation—one taking into account differing compliance costs. Emissions trading programs avoid this problem by providing an alternative means of compliance to facilities that face high costs of abatement and by providing an incentive to abate more to facilities with low costs of abatement. The result is a decentralized mechanism for offsetting emissions that does not detract from achievement of the environmental goal.

A third reason for enhanced environmental results is the greater ability to gain consensus on the environmental goal, and even adopt a more demanding goal, when flexibility is present. An important reason for the acceptance of more demanding environmental targets in conjunction with trading appears to be that the allocation mechanism can be used to win over those who might otherwise stand to lose the most from tighter regulations. The inclusion of emissions trading in Title IV of the Clean Air Act Amendments of 1990 broke what had been a decade-long stalemate on acid rain legislation. In the Northeastern NO_X trading program, state officials and regulators turned to emissions trading as a better means to come into attainment with the National Ambient Air Quality Standards for ozone, a goal which had long eluded these states (and a number of others) despite ample regulatory authority in the existing Clean Air Act. Similarly, regulators in Southern California adopted emissions trading in both SO_2 and NO_X as a more likely means of achieving emission reduction requirements that were already required. There also is evidence that more stringent emission standards were set for various categories of mobile sources because of the flexibility provided by the ABT programs.

Finally, some ancillary benefits of trading programs that would lead to improved environmental quality may be anticipated. Although evidence is limited so far, trading programs should create greater incentives for innovation in emission-reduction technologies than command-and-control regulations have created. While the latter may "force" some technological development, there is no incentive to go beyond the standard, and indeed a disincentive because investments in developing more efficient abatement technology might be "rewarded" only by a tighter standard. In contrast, the incentive to abate in cap-and-trade programs, where there is no specific standard for any single plant, is continuous and any improvements in abatement technology will result in allowance savings (Swift 2001). There is also empirical evidence that the Lead Trading Program led to more efficient adoption of lead-reducing technologies by refiners (Kerr and Newell forthcoming). As confidence is gained in the effect of these incentives on innovation, it should be feasible to reduce emissions more than would otherwise be the case. Another ancillary benefit is the significant improvement in the quality of environmental data that results from the monitoring requirements of emissions trading programs.[46] This information should contribute to better understanding of and solutions to remaining environmental problems.

Experience with the opt-in features of the Acid Rain Program and with the NO_X RECLAIM Program could be cited as counter-examples to the proposition that emissions trading has improved environmental performance when compared with a command-and-control alternative, but these instances must be placed in perspective, as we have attempted to do in the sections dealing with each. In the Acid Rain Program, the issuance of allowances reflecting "baseline errors" constituted only a small percentage of the total number of allowances and these extra allowances do not seem to have had any material effect on the achievement of the program's goals. Similarly, the additional RECLAIM NO_X emissions in 2000 represented a small percentage of the 2000 cap and, moreover, procedures were put in place to compensate for the shortfall in future years. It seems unlikely that a command-and-control program would have been any more effective in reducing emissions before and during the unique circumstances associated with the California electricity problems of 2000-01. California's electricity crisis was an extraordinary event and its principal lessons relate to the proper design of competitive electricity market institutions and the transition to them. It would be a mistake to draw many conclusions about environmental policy from the problems with California's experiment in electricity market deregulation.

C. Ability to Trade

Emissions trading has worked best when the allowances or credits being traded are clearly defined and tradable without case-by-case certification. The earlier view of emissions trading as a theoretically advantageous but mostly impractical concept, which reflected the disappointing early experience with the reduction credit approach to emissions trading, has been largely supplanted by a view that trading is a practical means for reducing emissions and lowering the cost of meeting environmental targets. This turnaround in perception reflects the increased and successful use of cap-and-trade and averaging approaches, which share the important features that the allowance or credit to be traded can be clearly defined and that each trade does not require an expensive pre-approval and certification process.

Allowances allocated under the Acid Rain, RECLAIM, and Northeastern NO_X Budget cap-and-trade programs provide pre-certified transferable rights to emit. Similarly, the credits in the Lead Trading and ABT programs can be readily determined using a simple formula that can be calculated by firms and easily verified by regulators. The creation of clearly defined and freely tradable "commodities"—principally in cap-and-trade programs but also in averaging programs—has removed the greatest impediment to better performance from emissions trading: the costly and time-consuming pre-approval of trades by the regulatory agency that was typical of the early EPA ET programs.

The clear definition and ready transferability of allowances and credits also encourages the emergence of intermediaries that provide liquidity and lower transaction costs. Intermediaries linking buyers and sellers exist in all emissions trading approaches, but their roles are different. In cap-and-trade and averaging systems—where the allowances or credits are typically homogeneous products that can be used by any source—intermediaries can aggregate sources of supply and demand, provide risk management services (e.g., options, swaps, and forward contracts),[47] and otherwise function as they do with other financial instruments.

In contrast, in reduction credit programs—in which the commodity for sale typically must be defined, measured, and verified in each case—the intermediaries facilitate trading not so much by buying and selling in the market, as by helping to interpret complex rules and to navigate the pre-approval process. Trades tend to be idiosyncratic events arranged between specific buyers and sellers with a price negotiated for each trade. Although markets exist for the credits created under these programs, their scope is limited, transaction costs are high, trades are infrequent, and financial instruments to manage risk develop much more slowly, if at all. Developing more effective programs based on emissions reduction credits will require more effort put into standardizing the baseline and verification processes in advance, so that the costs of participating are reduced.

Of course, a program's use of cap-and-trade or averaging does not guarantee clear definition, ready transferability, low transaction costs, or a successful program. The early bubble program was an averaging program, but case-by-case approval kept it from being successful. Similarly, a cap-and-trade program would get bogged down if pre-approval of trades were required in order to guarantee that trades did not negatively impact air quality in some way. Examples of such restrictions do not exist because regulators who have adopted cap-and-trade and averaging programs have wisely chosen to dispense with costly pre-approval and to resist temptations to complicate the transferability of allowances and credits.

D. Banking

Banking has played an important role in improving the economic and environmental performance of emissions trading programs. One of the surprising results emerging from this review of experience with emissions trading is the role of inter-temporal trading, or, the form that it most often takes, banking. Most of the attention given to emissions trading has focused on spatial trading, and indeed most of the cost savings seem to occur from this form of trading, as indicated by Table 1 (on page 7), which provides estimates of the cost savings attributable to spatial and temporal trading in the Acid Rain Program. Nevertheless, banking has been included in most of the emission trading programs reviewed in this report, and its inclusion appears to have improved program performance. The one major program without substantial temporal flexibility, RECLAIM, appears to have suffered because of it.

The role of banking in the improved environmental performance of both the Lead Trading Program in the mid-1980s and the later Acid Rain Program has been noted in a preceding section. In both programs, emissions reductions were accelerated as firms banked emissions allowances to smooth out the transition to the ultimately much lower level of allowable lead content and SO_2 emissions. The same pattern of banking and accelerated emissions reduction has emerged in the Northeastern NO_x Budget Program, even though the incentive to bank is diminished by the potential discount applied to the use of the banked allowances.

Although banking provides environmental and cost-saving gains, its greatest advantage may lie in the flexibility it provides for dealing with uncertainties. An inherent feature of cap-and-trade programs is that uncertainty in demand translates into variations in the price of allowances instead of variations in the quantity of emissions, as is the case with conventional emission rate limits and as would be the case with emission taxes. When abatement responses are not instantaneous, banking provides some flexibility for an otherwise fixed cap and uncertain demand for allowances. Banking does not eliminate vulnerability to unexpected shifts in demand, and it is not the only means of avoiding price spikes, but it does dampen potential allowance price volatility.[48]

E. Initial Allocation

The initial allocation of allowances in cap-and-trade programs has shown that equitable and political concerns can be addressed without impairing the cost savings from trading or the environmental performance of these programs. The initial allocation of allowances in cap-and-trade programs is a contentious process, as is the distribution of anything of value, but the political difficulty of allocation should not obscure the evidence from the three existing cap-and-trade programs that initial allocation has not compromised the achievement of environmental goals or the potential cost savings.

Imposing an emissions constraint creates a valuable property right for those who receive initial allocations. In cap-and-trade programs, allowances can be distributed either by auction, in which case the government is the immediate recipient of the gains from the valuable property rights, or by direct allocation, in which case the entities receiving the allowances, typically corporate incumbents, capture the gains. A rich literature has developed concerning the efficiency and equity implications of the distribution of auction revenues.[49] Governments could use the revenues to reduce existing taxes, to provide transitional assistance to workers displaced as a result of the environmental constraint (Barrett 2001; Greenwald et al. 2001), for any number of other worthy purposes, or could simply distribute the proceeds directly to households as an "environmental dividend."[50] Corporate profits may increase if allowances are grandfathered to incumbents, although the increased profits will be taxed and only the after-tax portion will be passed on to shareholders.[51]

The cap-and-trade programs described in this paper all have distributed allowances to participating units rather than auctioning them. The only program with an auction feature is the acid rain program; however, the auction accounts for a very small share (2.8 percent) of allowances, and, as if to prove the point, the proceeds of the auction are returned to the initial recipients from whose grandfathered allocations the auctioned allowances are initially withheld.[52] The reasons for the apparent preference for grandfathering are beyond the scope of this paper, but some comments can be made concerning the considerable differences in the manner of initial allocation and the lack of effect on program performance (as distinct from issues of equity and macro-economic efficiency).

The rules adopted to allocate allowances initially to participating units have differed significantly (Harrison and Radov 2002). Usually, historical data are used as the basis for a "once-and-for-all-time" grandfathered allocation, although some states in the Northeast NO_X Budget Program are updating the initial allocation on a lagged basis. The metric used in the grandfathering formulas has also varied considerably, from inputs, to output, to emissions. Furthermore, all levels of government—federal, state, and local—have been involved in making allocations, and allocations have been made both by legislative bodies and administrative agencies.

The many differences in how allowances have been allocated appear to have had no discernible effect on trading activity, the cost savings from trading, or the environmental effectiveness of the trading system. The likely reason for this outcome is that the dominant mechanism used to allocate allowances, grandfathering based on historical data, provides no incentive to alter production or abatement behavior in order to obtain more allowances in present or future periods and thus does not create distortions.[53]

IV. Considerations for Greenhouse Gas Control Programs

Every environmental problem possesses unique characteristics that strongly influence the regulatory programs that are adopted to address it. Some programs are local, such as RECLAIM; others, like the Northeastern NO_X Budget program, are regional; and still others are nationwide in scope, such as the Lead Trading, Acid Rain, and Mobile Source ABT Programs. The essential difference in all of these examples concerns the fate of the controlled emissions and the nature of the damages attributable to them. An important question with regard to the use of emissions trading to control greenhouse gas (GHG) emissions is then: What special considerations might apply to the design of a program to address climate change?[54]

For climate change, the fundamental issue is the contribution that various emissions make to the greenhouse effect, which depends upon the atmospheric concentrations of the various greenhouse gases (Reilly et al. 2003). Once emitted, greenhouse gases have long residence times in the atmosphere, usually measured in decades, centuries, and even millennia. Moreover, atmospheric currents ensure that emissions are dispersed quickly in the atmosphere, so that atmospheric concentrations of greenhouse gases are relatively uniform over the globe. In sum, emissions are uniformly mixed and long-lived, and the effects are cumulative and global.

A. Suitability of Trading

Emissions trading seems especially well suited as part of a program to control greenhouse gas emissions. The uniform mixing of GHG emissions in the atmosphere removes the chief concern limiting the scope of emissions trading in other applications and creates the opportunity to design trading programs without geographic limits defined by localized environmental impacts. Uniform mixing means that a ton of a given GHG will have the same effect on atmospheric concentration—and thus on climate change—regardless of whether the ton is emitted in California, New York, or elsewhere on the globe. Thus, trading can be national and international in scope, and the cost savings commensurately larger as the scope broadens. Moreover, the opportunities for cost savings through trading are greatest when the costs of control differ widely among sources. There is every reason to believe that the cost of reducing GHG emissions varies widely among sources and across countries. Accordingly, trading can provide the flexibility needed to allow GHG reductions to be achieved using the lowest-cost abatement options. Moreover, GHG emissions generally can be measured using relatively inexpensive methods (e.g., fuel consumption and emission factors), rather than the expensive continuous emissions monitoring required for some existing trading programs (Pew Center on Global Climate Change 2002).

In addition, the cumulative effect of greenhouse gases and their long duration in the atmosphere means that the *timing* of emissions reductions within a control program will not have a significant effect on atmospheric concentrations and on climate.[55] Thus, trading across time periods by banking offers still more potential for cost savings. And, as we have seen in other programs with phased-in emissions reduction requirements, which will almost certainly be the case for any GHG control program, banking can be a means of accelerating the required emission reductions.

A final feature that makes emissions trading particularly well-suited for a GHG control program, especially when it takes the form of a cap-and-trade program, is the incentive to take advantage of opportunities for less costly abatement that may lie outside the trading program. For a variety of reasons, ranging from concerns about measurement to varying political commitment, the least expensive abatement opportunities may lie outside the trading program. Examples would be domestic non-CO_2 GHG abatement possibilities (if the trading program initially focused on CO_2), the enhancement of forest and terrestrial sinks for CO_2, and reductions in developing countries that are not expected to accept GHG restrictions as soon or as demanding as those adopted by the relatively rich countries. Many issues must be dealt with in order to take advantage of these opportunities, but these difficulties can be addressed, and as we will emphasize below, should be addressed. The prerequisite, however, is an incentive to seek out opportunities for cheap abatement outside the cap. Although mechanisms could be devised to encourage cost-reducing abatement outside of the program under the emission tax or command-and-control approaches, these other approaches do not provide as exact and efficient an incentive for such abatement as does the emissions trading approach.[56]

In sum, although the specific nature of domestic and global measures to address climate change will evolve over time, few environmental problems appear so well suited to emissions trading as GHG emissions control.

B. Opt-in Features

Opt-in or voluntary features have a strategic role that is likely to warrant their inclusion despite the problems associated with them. Emissions trading has worked well in reducing costs and enhancing the achievement of an environmental goal when it is linked to a specific requirement, such as the cap in a cap-and-trade program or the mandatory standard in an averaging program. However, when participation has been voluntary, as in the opt-in features of the Acid Rain Program and also in the EPA ET programs, the results have been less encouraging. An unavoidable element of "moral hazard" is present and the regulator seems to be faced with the unenviable choice of eliminating it, and foregoing the cost savings from expanded emissions trading, or countenancing it, and accepting some degradation of the environmental goal.

One could in theory avoid the issues related to voluntary participation by requiring all sources to be covered by the trading program. However, considerations of transactions costs and politics frequently lead to a situation in which the trading program initially covers only some sources of the targeted emissions. For example, the Acid Rain Program covered only SO_2 produced by electricity-generating plants exceeding a certain size and it excluded industrial sources. Similarly, the RECLAIM program did not cover mobile sources, which are a major contributor of NO_X emissions in the Los Angeles basin. By the same token, GHG emission control programs are unlikely to cover all sources and sinks because of measurement problems, and are unlikely to cover all countries because of differences in political will and considerations relating to an equitable distribution of the global burden of pollution control between rich and poor countries. Given this reality, questions arise as to whether sources that are not included in the program by mandate can enter the program voluntarily—and if so, under what conditions.

The answers to these questions require a balancing of the expected costs and benefits of allowing opt-in participation. The environmental integrity of the Acid Rain Program was not significantly impaired by the opt-in provisions, and in retrospect measures could have been taken to lessen the impact still more. At the same time, the cost-reducing benefits were small, since the units that opted-in and reduced emissions did so for only a few years before they were subject to the mandatory cap. While the opt-in provisions of the Acid Rain Program may well be judged (in retrospect) not to have been worth the effort, the same cannot be assumed to be the case for GHG emission control.

Two arguments strongly favor including opt-in provisions in any GHG cap-and-trade program. The first is that much has been learned in two decades of experience with analogous requirements to set baselines in various environmental and non-environmental credit reduction programs. As discussed in Harrison et al. (2000), the worst abuses of opt-in features have been avoided in other programs.[57] For example, the U.S. EPA has developed models to estimate the likely future baseline status of natural resources damaged by oil spills or other environmental insults. Similarly, private firms have developed methods of estimating baseline energy use for purposes of determining compensation for efficiency-enhancing programs. Although admittedly not perfect, these and other mechanisms can be used as guidelines for the development of similar procedures for setting reasonable baselines for GHG emission reduction programs.

The second argument for incorporating opt-in features is strategic—to extend the caps in domestic programs to include non-capped sources and sinks domestically and abroad. The global nature of climate change requires that the control program eventually be global, but for a variety of technical, institutional, and political reasons, a comprehensive control program will not be achieved in the near term. But, if rich countries provide an example—as well as an incentive through the value created in their own allowance markets—opt-in projects will provide the mechanism by which the market and the caps can be broadened geographically and extended to include both CO_2 sinks and greenhouse gases in addition to CO_2. Trading in reduction credits—with all of its well-known difficulties—will play an important role in developing inventories and measurement protocols for non-capped sources and sinks at home and abroad. In effect, each emissions reduction project will be an experiment that tests the feasibility of including various types of sources and sinks in the program.

Opt-in projects in developing countries may provide similar experience and incentives that expedite the inclusion of activities contributing to climate change under the various caps. Some developing country emission sources, notably large stationary ones, are readily identifiable; measurement techniques are available; and there is no reason to foreswear cheap abatement opportunities while waiting for a more comprehensive global regime to emerge. Each project constitutes an incremental extension of the emission caps and the incentives will be strong to extend the caps to include related facilities, a whole sector, or even a country. The greater the scope of the caps, the less **leakage** (i.e., shifting emissions from capped to uncapped sources), and the less costly it will be to establish credible baselines. This will lower transaction costs and provide trading opportunities to the advantage of both buyers and sellers. Of course, opt-ins alone will not create an *equitable* scheme for sharing the burden of global emissions reductions. That will require international negotiation and diplomacy beyond the efforts of a single country establishing a domestic program. But opt-in projects can prepare the way for these international developments.

V. Conclusions

Emissions trading has emerged as a practical framework for introducing cost-reducing flexibility into environmental control programs and reducing the costs associated with conventional command-and-control regulation of air pollution emissions. Over the last two decades considerable experience with various forms of emissions trading has been gained, and today nearly all proposals for new initiatives to control air emissions include some form of emissions trading. This report has attempted to summarize that experience and to draw appropriate lessons that may apply to proposals to limit GHG emissions. In doing so, we hope that the reader has gained a better understanding of emissions trading and the reasons for its increasing importance as an instrument for addressing environmental problems.

Six diverse programs constitute the primary U.S. experience with air emissions trading. The EPA's early attempts starting in the late 1970s to introduce flexibility into the Clean Air Act through netting, offsets, bubbles, and banking were not particularly encouraging. Most of the potential trades, and economic gains from trading, in these early systems were frustrated by the high transaction costs of certifying emission reductions. The first really successful use of emissions trading occurred in the mid-1980s when the lead content in gasoline was reduced by 90 percent in a program that allowed refiners to automatically earn credits for exceeding the mandated reductions in lead content and to sell those credits to others or bank them for later use.

The Acid Rain or SO_2 allowance trading program for electricity generators, which has become by far the most prominent experiment in emissions trading, was adopted in 1990 and implemented beginning in 1995. This innovative program introduced a significantly different form of emissions trading, known as cap-and-trade, in which participants traded a fixed number of allowances—or rights to emit—equal in aggregate number to the cap, instead of trading on the differences from some pre-existing or external standard as had been the case in the early EPA trading programs and the lead phase-down program.

Another cap-and-trade program, the RECLAIM program for both SO_2 and NO_X emissions, was developed and implemented at the same time as the Acid Rain program by the regulatory authority in the

Los Angeles Basin as part of its efforts to bring that area into attainment with National Ambient Air Quality Standards. The RECLAIM program is the first instance of emissions trading both supplementing and supplanting a pre-existing command-and-control structure that theoretically was capable of achieving the same environmental objective. The standards of the pre-existing command-and-control system largely determined the level of the cap, and the program's ten-year phase-in design and trading provided the flexibility that led to the achievement of environmental goals that had been previously elusive. RECLAIM also introduced trading among different sectors.

The 1990 Amendments to the Clean Air Act also provided enabling legislation for two other emissions trading programs. Emissions from mobile sources were more effectively and efficiently controlled by the introduction of mobile source averaging, banking, and trading programs. The mobile source programs followed the example of the lead phase-down program by allowing firms to create credits automatically for any reductions beyond a required uniform emission standard and to use these credits in lieu of more costly reductions elsewhere or later within the company and to sell them. The 1990 Amendments also provided the mechanism that encouraged states in the Northeastern United States to adopt cap-and-trade programs to control NO_x emissions that contributed to ozone non-attainment in that region of the country. As was the case in the RECLAIM program, emissions trading was adopted as a means to attain environmental objectives more quickly and cost-effectively than had proved possible through conventional command-and-control regulation.

There are many lessons to be gained from the experience with these six programs, but the five most important lessons can be summarized as follows. First, the major objective of emissions trading, lowering the cost of meeting emission reduction goals, has been achieved in most of these programs. Second, emissions trading has not compromised the achievement of the environmental goals embodied in these programs. If anything, and this is perhaps surprising, the achievement of those goals has been enhanced by emissions trading. Third, emissions trading has worked best in reducing costs and achieving environmental goals when the credits being traded are clearly defined and readily tradable without case-by-case certification. Fourth, temporal flexibility, i.e., the ability to bank allowances, has been more important than generally expected, and the ability to bank has contributed significantly to accelerating emission reductions and dampening price fluctuations. Fifth, the initial allocation of allowances in cap-and-trade programs has shown that equitable and political concerns can be met without impairing either the cost savings from trading or the environmental performance of these programs. In addition, the success of any emissions trading program requires that emissions levels can be readily measured and compliance verified and enforced.

All of these five lessons are relevant when considering the use of emissions trading in a program aimed at reducing GHG emissions. In fact, emissions trading seems especially appropriate for this environmental problem. Greenhouse gas emissions mix uniformly and remain in the atmosphere for a long time. Thus, it matters little where or when the emissions are reduced, as long as the required cumulative reductions are made. These specific characteristics of GHG emissions eliminate two of the concerns that have limited the scope of emissions trading in many other programs.

Although an effective GHG mitigation program must eventually be global in scope and comprehensive in its coverage of pollutants and economic sectors, the likelihood that control efforts will be limited initially to the richer countries, the more easily measurable gases, and perhaps to certain sectors of the economy introduces another consideration. The ability to induce initially uncapped sources to participate voluntarily in the early efforts will reduce costs and prepare the way for extending the caps. Thus, providing opportunities to opt-in for uncapped sources that can reduce emissions at lower cost than those within the cap has a strategic value beyond the potential cost savings. Although some existing programs with voluntary provisions have revealed opportunities for misuse, these problems can be managed more successfully now with the benefit of experience. The strategic value of opt-in provisions in any GHG emission control program makes their inclusion highly desirable.

Emissions trading has come a long way since the first theoretical insights forty years ago and the first tentative application almost a quarter of a century ago. Since then, the use of emissions trading has expanded steadily and significant experience has been gained. Although not the dominant form of controlling pollution in the United States or elsewhere, emissions trading now seems firmly established as a valuable instrument and its future use seems sure to increase. Our review of experience over the past quarter century suggests that this trend toward greater use of emissions trading will improve the performance of environmental regulation, including efforts to control GHG emissions.

Glossary

Allowance: The right to emit one unit (e.g., one ton) of a pollutant or greenhouse gas such as carbon dioxide (CO_2), generally distributed by the governing authority for a cap-and-trade program.

Averaging program: An emissions trading program in which an overall average emissions rate is set (e.g., emissions per unit of input or output), and firms may have different emission rates for individual facilities as long as the required average is achieved. In some cases, there is a maximum emission rate (or cap) set. Averaging programs do not constrain the total number of tons that can be emitted.

Banking: Banking is a form of inter-temporal substitution that allows sources to reduce emissions below their requirement in one year and bank "surplus" allowances for use or trade in future years.

Baseline: The level of emissions that would have taken place without the given emissions regulations. Baselines must be calculated when implementing credit-based programs.

Borrowing: A form of inter-temporal substitution related to banking. Under a borrowing program, a source of pollution is allowed to emit above its requirement in a given year (i.e., "borrow" allowances) in exchange for the obligation to emit below its requirement in future years, when the "borrowed" amount would be "repaid."

Cap-and-trade program: An emissions trading program in which policy-makers set an overall limit or cap on emissions of one or more pollutants. Rights to emit the pollutant(s), also known as allowances, are distributed in some way to participants, who are then allowed to trade them among themselves.

Command-and-control program: A program that sets individual and specific emission standards for various facilities without any flexibility to average or trade allowances.

Continuous Emissions Monitoring System (CEMS): A system for continuously monitoring emissions from a source, for instance by the installation of probes or other sensing instruments in the exhaust stack of a power plant.

Credit or emissions-reduction credit: The right to emit one unit (e.g., one ton) of a pollutant in excess of what would normally be permitted. Credits are typically awarded for reducing emissions below a baseline or existing emissions cap. Under some trading programs, credits and allowances can be used interchangeably.

Early reduction credit: A mechanism to compensate companies that voluntarily reduce emissions prior to the introduction of a cap-and-trade program. The credits allocated can be used to meet requirements once the cap-and-trade program goes into force.

Grandfathering: A method of initially distributing emissions allowances using only historical data. The data used as the basis for the grandfathered allowances can be on a variety of types of facility activity, including emissions, input, or production.

Greenhouse gases: Atmospheric gases that change the Earth's radiative balance by absorbing heat. Six gases and gas families are specifically covered in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and three industrial gas families, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). See Reilly et al. (2003) for a more complete discussion.

Heat input: The energy content of fuel used to fire power plants (usually measured in joules or Btu). Historical heat input has been used for grandfathering allocations under various cap-and-trade programs.

Initial allocation: A term used to refer to the method by which emissions allowances are distributed by a government or regulator in a cap-and-trade program. Allowances are either auctioned or distributed freely based on a variety of criteria.

Leakage: The "migration" of emissions-intensive activities from an area required to participate in a cap-and-trade program to an area not covered by the emissions cap. The result is that emissions are reduced within the capped region, but are increased outside it, resulting in lower overall emission reductions.

Mobile sources: Sources of emissions that are not geographically fixed, including motor vehicles (including motorcycles), large non-road engines such as those used in construction and agriculture, locomotive engines, marine engines, engines used in recreational equipment, and small utility engines (e.g., lawn mowers).

National Ambient Air Quality Standards: Standards established by the U.S. EPA under Section 109 of the Clean Air Act. The Clean Air Act calls for the Administrator of EPA to set national primary and secondary ambient air quality standards for each air pollutant for which air quality criteria have been issued. The primary standards are to be set "to protect the public health" including "allowing an adequate margin of safety." The secondary standards are set "to protect the public welfare from any known or anticipated adverse effects." Section 110 of the Clean Air Act calls for states to develop State Implementation Plans that provide for implementation, maintenance, and enforcement of the primary and secondary ambient air quality standards. These standards are periodically reviewed and possibly revised.

Opt-in program: A type of voluntary program that allows certain eligible facilities to participate in an emissions trading program even though they are not required to do so. Sources will typically opt-in if they believe they will have lower emissions reduction costs than other participants, and therefore will be able to profit from the sale of surplus allowances.

Permit: A formal document which gives to its holder the right to emit certain kinds of pollutants, subject to various constraints and restrictions—one of which may be that the holder comply with the rules of an emissions trading program. Note: some authors use *permit* interchangeably with *allowance*.

Reduction credit program: An emissions trading program in which participants can earn tradable credits if they reduce their emissions below some approved baseline. Credits can then be sold in the emissions market to firms that expect to have emissions higher than an existing cap or baseline.

Stationary sources: Sources of pollution that are fixed in place, such as electricity generation units and industrial facilities.

Updating: A method of initially distributing allowances in which participants' future allocations change based on their current or future activity. This method contrasts to the grandfathering approach, in which firms receive their allocations regardless of their current or future activities.

Vintage: The year(s) in which the allowance in a cap-and-trade program can legally be used to cover emissions. For programs that allow banking and borrowing, allowance vintages may not be relevant.

Voluntary programs: Programs that allow pollution sources to undertake voluntary emissions reductions and receive credit for those emissions reductions if they so choose. Typically, only volunteers would be required to monitor emissions and to achieve emissions targets. Mandatory programs may be combined with voluntary features, for example, if certain firms must comply with the emissions targets but others are allowed to participate if they choose to. Voluntary features of otherwise mandatory programs are typically referred to as opt-in components.

Endnotes

1. See Harrison 1999a for additional details on how emissions trading markets operate and how allowance prices are determined.

2. In the context of GHG emissions, averaging programs sometimes are referred to using other terms, including "rate-based programs" and "relative targets."

3. Some of the special issues involved in establishing international trading programs are considered elsewhere; see Ellerman (1999) and Harrison (1997). The issues involved in currently observable GHG trading are discussed in Rosenzweig et al. (2002).

4. Other studies provide more comprehensive lists of previous and current emissions trading programs (see, e.g., Harrison 2002). The six programs included in this paper represent the bulk of the actual experience with emissions trading.

5. The lessons in this paper are applicable for countries with the necessary legal and institutional infrastructure to implement emissions trading programs effectively. In particular, we assume that the accurate monitoring of emissions, the effective enforcement of applicable regulations, and basic commercial contract law are all well established. Without these basic institutions, emissions trading would not be feasible.

6. These descriptions draw on Harrison (1999a) and Harrison (2002). Several of the emissions trading programs discussed in these references are not included in this paper because their experience was judged not to provide major additional insights. The programs are described in rough chronological order.

7. These programs are referred to as the EPA ET to distinguish the specific programs from the general concept of emissions trading.

8. Brokers and other intermediaries have evolved in some jurisdictions to put buyers and sellers of these credits together, but substantial fees are charged because of the complexities associated with putting together a "trade" that complies with EPA's administrative and regulatory requirements. In the Los Angeles region, for example, broker fees vary between 4 percent and 25 percent of the value of the trade, depending on the complexity of the transaction; administrative fees to government agencies in Los Angeles can total about $25,000 per trade, with the approval process taking from five to 12 months (Foster and Hahn 1995). Moreover, only about 20 percent of proposed trades are fully approved as proposed.

9. Note that the program did not cap the total lead emissions from gasoline, because refiners had to meet an average rate per leaded gallon and the number of leaded gallons was not controlled. This is a characteristic of all averaging programs. In this particular case, however, lead eventually was eliminated from gasoline.

10. Title IV also includes a requirement for reducing nitrogen oxide (NO_X) emissions with a provision for averaging plans that allows a firm to establish a bubble across all of its affected generating units. This component of Title IV will not be discussed further because the Northeastern NO_X Budget Program and the prospective NO_X SIP call, both of which address ozone non-attainment, have superseded most of its requirements. We use the term "opt-in" to refer generically to all the voluntary programs associated with the SO_2 reduction requirements of Title IV.

11. See Ellerman et al. (2000) for a detailed discussion of the trends in SO_2 emissions and the effects of Title IV.

12. This pattern of emission reductions corresponds to that predicted by economic theory in a phased-in emission reduction program where banking is allowed (Schennach 2000; Ellerman and Montero 2002).

13. Analyses conducted for EPA during development of the Acid Rain trading program indicated the likely importance of intra-firm trading (ICF, Inc. 1989).

14. Commissions declined from about 1.5 percent to 0.5 percent in the first years of trading (Ellerman et al. 2000).

15. Much of the cost savings from spatial trading and from banking are due to intra-utility trading, i.e., trading of allowances among units under common ownership. Ellerman et al. (2000) note (pp. 154–161) that in the first three years of Phase I, from 25 to 30 percent of the allowances needed to cover emissions at affected units with emissions greater than the allowance allocation came from sources external to the utility, or by inter-utility trading.

16. Carlson et al. (2000) develop estimates of cost savings for Phase I and Phase II years. For 1995 (Phase I), they estimate gains from trade equal to 13 percent of the "No Trading" costs. In 2005 (Phase II), they estimate that overall compliance costs will be reduced by about 37 percent relative to "No Trading" costs. See also Stavins (1998) for a review of the SO_2 program.

17. Potential cost savings of as much as 95 percent have been estimated for some theoretically possible emissions trading programs (Tietenberg 2000). Note that a confusion of allowance prices with average incurred costs led official Administration spokesmen to claim cost savings of 90 percent for Title IV (Smith et al. 1998).

18. Note that under Title IV, an allowance is defined as a "limited authorization to emit" SO_2 and not a property right.

19. Materials balance methods rely on the law of conservation of matter to account for all the pollutants contained in the fuel combusted. The chemical content of all fuel is determined by frequent sampling and diagnostic tests of the samples at independent laboratories. These reports are reliable since they form the basis for the transfer of billions of dollars annually between the sellers and buyers of fuel. Estimates of SO_2 (and other) emissions prior to the requirement in Title IV to install CEMS on all power plants were made using materials balance calculations.

20. This term has a meaning in emissions trading that differs from its use in other contexts, where it implies exemption from tax or regulatory provisions.

21. The implications of alternative initial allocation methods have been discussed in several recent papers and reports. See Goulder et al. (1999), Burtraw et al. (2001), and Dinan (2002) for discussions in the context of a potential U.S. cap-and-trade program for CO_2 emissions. See Harrison and Radov (2002) for a discussion of issues in the context of the proposed European Union trading program for GHG emissions.

22. The one major exception was the provision that provided bonus allowances for installing scrubbers in Phase I. Bonus allowances for energy efficiency programs were of little consequence.

23. McLean (1997) points out that with interconnected electric grids, participating Phase I units could shift electrical load to non-participating Phase II units, whose emissions could increase and undermine the Phase I emissions reduction goal.

24. The voluntary provisions for electric generating units are formally known as the substitution and compensation provisions, while the voluntary provisions for industrial units are known as the industrial opt-in program. A conservation and renewable energy reserve was established to provide additional allowances for utilities adopting energy conservation programs or introducing additional renewable energy sources, but this provision has seen little use and will not be discussed further.

25. Eligible sources were largely those with common ownership or associated in some manner with the 263 electricity-generating units required to participate in Phase I. The number of utility sources opting-in varied from year to year, but 111 generating units constituting approximately 20 percent of the affected capacity and 12 percent of the allowances distributed during Phase I remained in the voluntary program for all five years of Phase I. The peak year was 1995 in which voluntary units numbered 182 and constituted 32 percent of the electric generating capacity subject to Title IV and 16 percent of the allowances issued for that year.

26. Certain features of Title IV's voluntary programs made the creation of paper credits more likely. Chief among these was the ability of units to decide each year whether they would participate and to make that choice as late as November 30 of each compliance year. Units that considered volunteering knew how many allowances they would receive for the year and they could wait until nearly eleven of the twelve months of the year had passed before deciding to participate.

27. Montero (1999) examines the importance of different incentives on an eligible unit's decision to become a substitution unit. These incentives include the potential to receive allowances through baseline errors ("paper credits"), the potential to achieve cost-savings (i.e., reduce emissions at a cost lower than the cost of an allowance), and NO_X grandfathering benefits. Montero is one of the co-authors of Ellerman et al. (2000) and an entire chapter of this latter work is dedicated to this problem and provides some updating to Montero's earlier work. See also McLean (1997) and Environmental Law Institute (1997).

28. The original RECLAIM proposal included 38 separate trading regions, corresponding to the regions used for the offset program. This detailed geographic division was abandoned as a result of the plausible fear that the trading markets would be too thin. See Harrison (1999b).

29. SO_2 allowances in the Acid Rain Program are distributed for 30 years forward on a rolling basis, while RTCs are distributed indefinitely into the future.

30. Because the published data do not differentiate the vintage of the RTCs traded, it is not possible to provide information on the percentage of RTCs of a particular vintage that are traded.

31. The early problems with CEMS occurred because of technical malfunctions of the CEMS equipment.

32. The price for the 1999 vintage allowance also increased because RTCs from the 1999 July cycle could be traded and used to cover emissions through June 2000 (South Coast Air Quality Management District 2001a, p. 5).

33. In brief, the generating units subject to NO_X RECLAIM requirements became the marginal units for a significant number of hours, thus setting prices for wholesale electricity throughout California. Moreover, a large fraction of electricity demand under California's new wholesale market institutions was supplied through the spot market, where demand was effectively insensitive to prices, rather than through long-term contracts. As a result, the huge spikes in spot market prices for electricity, caused in part by the spike in NO_X RTC prices, became an enormous financial burden on distribution utilities, consumers, and the state of California.

34. Questions have been raised about whether unregulated electricity suppliers manipulated the NO_X RTC credit market as well as electricity and (possibly) natural gas markets. We offer no opinion on this issue.

35. This is the case because regulated prices would have been based on the average costs of generating electricity, including the average costs of NO_X RTC credits rather than the marginal cost of the generating units with the highest marginal spot fuel and RTC costs that cleared the spot electricity market. In addition, further price increases resulting from unregulated generators exercising market power (Joskow and Kahn 2002; Borenstein, Bushnell, and Wolak 2002) would not have occurred under regulation. Finally, the disruptions caused by divestiture, the hasty movement to a set of complex new wholesale market institutions, inelastic short-term electricity demand, and the excessive amount of electricity demand supplied out of the spot market probably undermined rational forward contracting and investments in NO_X controls by the new owners of most of the fossil-fired power plants in California (Joskow 2001) and shifted the burden of short-term price volatility to economic agents (distribution utilities and retail consumers) who did not have the ability to manage it.

36. The EPA Office of Air and Radiation website has information on various ABT programs. See http://www.epa.gov/oar/oarhome.html.

37. The ABT program for automobiles and light-duty trucks is distinct from the Corporate Average Fuel Efficiency (CAFE) Program, which is an averaging program for fuel efficiency without inter-firm trading and is administered by the Department of Transportation. See Committee on the Effectiveness and Impact of CAFE Standards (2001).

38. In 1996, Navistar sold credits for 5 tons of particulate matter to Detroit Diesel.

39. Several ex ante studies have simulated cost savings, but no ex post evaluations have been conducted. See Harrison (1999a) and Rubin and Kling (1993) for examples of the former.

40. The average emission standard was set to reduce emissions by 75 percent, based in part on information that showed that the marginal cost per ton increased dramatically beyond a 75 percent reduction. The marginal cost curve was based upon detailed information on emission control technologies and on the assumption of "perfect" trading, i.e., that all cost-reducing trades took place (U.S. Environmental Protection Agency 1996).

41. The twelve include the six New England states (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut) plus six Mid-Atlantic States (New York, New Jersey, Pennsylvania, Maryland, Delaware, and Virginia).

42. Technically, these phases are the second and third of a three-phase program, the first phase of which consisted of re-labeling existing technology-based requirements and did not involve emissions trading.

43. See Nichols (1997) for an analysis of issues related to banking and the development of the concept of flow control in the context of the NO_x Budget program.

44. Vermont and Maine decided to operate traditional permit-based programs because the small number of sources in their states (less than three in each state) did not justify the administrative expenses of developing an emissions trading program. Maryland's program was delayed for a year by a lawsuit from a power company. Virginia did not join the NO_x Budget Program and has not taken any action to regulate sources. See Farrell (2000).

45. Farrell (1999) reports that "wrong way" trades (net allowance sales from upstate New York and New Hampshire, which could only have been upwind, account for only about 3 percent of the total allocation. Moreover, at the time of his report, brokers and speculators owned many of these allowances and thus the geographic location of the corresponding emissions was not determined.

46. Although emissions monitoring could be, and sometimes is, required of command-and-control regulation, more typically emissions are not monitored since compliance is determined by inspection to ensure that the mandated equipment is installed and working or that the mandated practices are being followed.

47. These financial derivatives provide the means for reducing specified risks, such as the price of allowances that might be needed two years in the future.

48. A "safety valve" has been proposed as a mechanism for avoiding price spikes (see, e.g., Pizer 1999). This mechanism allows sources subject to a cap-and-trade program to purchase additional allowances at the "safety valve" price and thereby to avoid an "excessive" allowance price if demand for allowances is greater than expected. If the safety valve is used, however, overall emissions will exceed the cap that has been set unless there is some other mechanism to provide offsets for the increased emissions. Jacoby and Ellerman (2002) provide a discussion of the origin and role of the safety valve concept.

49. See Goulder et al. (1999) for discussions of the major efficiency effects of auctions. For a general discussion of the distributional impacts of emissions trading, see Harrison (1996).

50. A lobbying organization, Americans for Equitable Climate Solutions, has recently been established in Washington, D.C. for the purpose of advocating this last use of auctioned revenues. The idea has been included in both the Clean Power Act of 2003, S. 366, 108th Congress, sponsored by Senator James Jeffords (I-VT), and the Climate Stewardship Act of 2003, S. 139, 108th Congress, sponsored by Senators John McCain (R-AZ) and Joseph Lieberman (D-CT).

51. Research by Terry Dinan and colleagues at the Congressional Budget Office indicates that about 85 percent of the after-tax rent distributed through direct stock holdings and mutual funds would go to the top quintile of the income distribution. Work is currently underway to estimate the distribution of the part passing through pension funds and 401(k) plans (Private communication from Dinan to Ellerman 2002).

52. One other program, the UK's Emissions Trading Scheme for greenhouse gases, has made use of an auction mechanism. However, the UK program is an unusual hybrid between the credit-based and cap-and-trade options, and its voluntary nature required the use of a reverse auction of government incentives. The program also relied on a form of grandfathering to set baselines.

53. See Harrison and Radov (2002) for analyses of the circumstances in which the method used to distribute initial allocations could reduce the cost savings from emissions trading or otherwise distort allowance or product markets. See also Burtraw et al. (2002).

54. Our focus in this section on a domestic program should not be taken as suggesting less importance for the design of international mechanisms for emissions trading, such as those included in the Kyoto Protocol. We focus on domestic programs both because the existing experience is most relevant to these programs and because domestic programs are likely to be the building blocks of international regimes. See Ellerman (1999).

55. This point about the indifference to the timing of emissions reductions within some control program does not imply that the initiation of some program to control GHG emissions is also a matter of indifference.

56. Many studies have estimated gains from international trading of GHG emissions. See, e.g., Edmonds et al. (1999), and Weyant and Hill (1999) (which provides a review of international modeling results). Most of these assume completely efficient markets with no transaction costs, but the point is that these cost savings will be realized, albeit slowly, only if the incentive is provided by a mandatory cap in some country.

57. Harrison et al. (2000) provide analyses of the experience with setting baselines in 15 environmental and non-environmental programs and the implications for setting GHG baselines.

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notes

This report examines U.S. experience with emissions trading to provide lessons for future applications, including efforts to address climate change. The Pew Center on Global Climate Change was established with a grant from the Pew Charitable Trusts and has been charged with bringing a new cooperative approach to the debate on global climate change. The Pew Center continues to inform the debate by publishing reports in the areas of policy (domestic and international), economics, environment, and solutions.

Pew Center on Global Climate Change
2101 Wilson Boulevard
Suite 550
Arlington, VA 22201
Phone (703) 516-4146
www.pewclimate.org

RGGI At One Year:
An Evaluation of the Design and Implementation of the Regional Greenhouse Gas Initiative

ENE
Environment Northeast

February 2010

The Regional Greenhouse Gas Initiative (RGGI) is the nation's first mandatory greenhouse gas cap and trade system. After one full year of operation, including a series of successful carbon auctions, an evaluation of a real world cap and trade program in the United States is appropriate. For policy makers and the public alike, it is important to understand the logic behind RGGI's design and to evaluate program implementation so that lessons learned can inform the development of regional and national climate policy.

RGGI Profile:

- 10 States (ME, MA, NH, VT, RI, CT, NY, NJ, DE and MD)
- Applies to all fossil fuel-fired power plants 25 MW or greater
- Went into effect Jan 1, 2009
- Latest of 6 quarterly auctions conducted December 2, 2009
- Next auction March 10, 2010
- Initial regional cap is 188 million tons CO_2
- Cap is two-phase:
  - Stabilization at initial level for 2009-2014.
  - 2.5% reduction per year 2015-2018 for total 10% reduction
- Compliance period is 3 years; allowances equivalent to 2009-2011 emissions due March 1, 2012.

The evaluation provides graded assessments of program design and performance to date, followed by "notes" that provide additional contextual information and recommendations based on experience. Five key components of cap and trade are addressed:

- **Auctions** – how were auctions designed, and how successful have auctions been?
- **Funding** – what programs did states intend to support with allowance value, and have states followed through on funding commitments?
- **Offsets** – how was the offset mechanism designed, and how has is operated?
- **Cap Level** – was the emissions cap set accurately, and how does it relate to actual emissions?
- **Governance** – what organizational structures were created, and have they been effective?

Auctions

Design: Grade (**A**)

RGGI states decided to sell 87% of allowances in auctions open to any participant. Auctions ensure fair and transparent program design, while avoiding market distortion by awarding allowances to those who value them most. The design of regionally-administered auctions was informed by analysis of different

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EXHIBIT 3

auction mechanisms by the University of Virginia, Resources for the Future, and the California Institute of Technology.[1]

Implementation: Grade (**A**)

To date, over 171 million allowances have sold at six successful RGGI auctions, raising over $494 million. The quarterly online auctions are conducted by the independent contractor World Energy Solutions, with public disclosure of results and proceeds returned to member states.

Note:

- *The decision to auction 87% of allowances marks a positive departure from free allocations in prior cap and trade systems, such as the EPA's Acid Rain Program and the European Trading System.*
- *RGGI has had minimal impacts on consumer prices. In 2009 RGGI allowances sold for an average price of $2.91/ton, adding about 0.9% to retail electricity prices in New England[2] while raising revenue for strategic investments aiding in the transition to a clean energy economy.*

Funding

Design: Grade (**A**)

The emissions allowances at the heart of cap and trade are a new public resource, and RGGI states wisely chose to use allowance value to benefit consumers. Allowances confer the right to dispose of emissions in the public commons (the atmosphere), and during the design process states accordingly agreed to direct at least one-quarter of allowances to public benefit. However, based on economic modeling of various allowance allocations and a recognition that markets had changed since electricity restructuring, member states independently opted to direct two-thirds of allowance value to energy efficiency. The logic behind efficiency is straightforward. When consumers use energy more efficiently, demand for electricity declines, bringing down supply costs and power plant emissions. Lower emissions reduce demand for allowances, thus decreasing allowance prices and the overall program cost. Capturing the dual benefits of efficiency – lower supply costs and lower carbon costs – is one of RGGI's greatest achievements, and should ensure that costs remain low over time.

Implementation: Grade (**B**)

RGGI states have for the most part followed through on funding plans, but a number of states have deviated from commitments. To date, the vast majority of the $494 million in RGGI funding is flowing to the originally designated uses. Approximately $275 million is going to energy efficiency, which, based on past program results, will save electricity consumers over $800 million.[3]

The pitfalls of budgetary politics have been exposed in Maryland and New York, where RGGI auction revenue is being diverted from planned efficiency and clean energy investments, and other states may be considering similar action. In April, Maryland transferred $70 million in RGGI funding from efficiency investments to short-term rebates, and New York is using $90 million of revenue to fill state budget

[1] *Auction Design for Selling CO2 Emissions Allowances Under the Regional Greenhouse Gas Initiative*, available at: http://rggi.org/docs/rggi_auction_final.pdf

[2] Calculated by multiplying the 2009 average RGGI allowance clearing price of $2.91/ton by the New England marginal emissions rate of 1,004lbs/MWh (Independent System Operator – New England) to achieve a price impact of $1.46/MWh, or 0.9% of the average 2009 New England retail electricity price of $156.40/MWh (Energy Information Administration).

[3] Based on efficiency program experience in MA, CT, ME and RI, where programs typically save about $3 for every $1 invested.

deficits. While these diversions will not undermine the RGGI cap, they run counter to commitments by RGGI states to minimum funding levels for clean energy investments, and demonstrate the vulnerability of long-term transformative programs to short-term political expediency.

Notes:

- *RGGI states' commitment to energy efficiency provides an important precedent for federal policy makers, who can establish similar cost controls though significant allocations to efficiency and consumer benefit in federal climate legislation*

- *RGGI states must avoid raiding RGGI funds and must implement established funding plans in order to deliver continuing consumer benefit and keep down the costs of the program*

Offsets

Design: Grade (**A**)

To a limited extent, RGGI allows power companies to purchase and use emissions "offsets," which represent reductions in GHGs achieved outside of the electric sector. The emissions reductions must be real, surplus to business-as-usual (additional), verifiable, permanent, and enforceable. In determining the eligibility of offset project, RGGI used a standardized method that avoids the administrative complexity of evaluating projects on a case-by-case basis.

This standardized approach was developed in response to the inefficient operation of Kyoto Protocol-sanctioned Clean Development Mechanism (CDM), wherein certification of offset projects was overwhelming administrative capacity and significantly delaying offset development. Standards provide offset developers with the clarity required for investments and reduce administrative burdens. For example, rather than assessing the financial viability of each project in order to determining whether or not the project would happen without offset funding (as required in the CDM), RGGI requires demonstration that a project is not required by law, is not receiving certain types of public funding, and is not commonplace within the sector, as determined by percentage market penetration or other relevant metrics.

Implementation: Grade (**incomplete**)

Thus far no offset projects have been developed in RGGI, as allowance prices have been low due to lower than expected emissions and offsets have been unnecessary.

Note:

- *While other regional and federal cap and trade systems have not yet determined whether to adopt standards-based offset methodologies, RGGI has contributed significantly to the development of an effective, scalable offset mechanism.*

Cap Level

Design: Grade (**C**)

The RGGI cap level was initially set slightly higher than historical emissions by member states. At the time the cap level was negotiated, assumptions that have subsequently proved inaccurate were made about increases in electricity demand and other factors. For example, it was assumed that electric sector emissions would continue to grow at approximately 1% annually, and the cap was thereby set above historical emissions estimates. However, subsequent events, particularly a steep decline in emissions due to low natural gas prices, the economic downturn, and increased efficiency investments have combined to produce emissions substantially lower than the cap. RGGI could have included mechanisms designed to adjust the cap to better reflect actual emissions at the start of the program (the program was finalized at the end of 2005 but did not start until the beginning of 2009), rather than only allowing for a consideration of cap adjustment as part of a wider program review scheduled for 2012.

Implementation: Grade (**incomplete**)

Available data suggest that emissions in the region fell approximately 25-30% below the RGGI cap in 2009.[4] Low emissions were caused by decreased economic activity, successful efficiency programs, and – most significantly – increased utilization of low-emitting natural gas due to drops in the market price for natural gas. This decline in emissions is a good thing, not only because RGGI was designed to reduce emissions, but also because it demonstrates such a decline can happen rapidly, at low allowance prices, as lower carbon fuels become economical.

However, ensuring lasting emissions reductions in the electricity sector – which was the original intent of the program – depends on tightening the cap. Given that RGGI states were taking independent action, it is not surprising that a generous cap was established. However, the gross discrepancy between actual emissions and the cap (in 2009 RGGI states far exceeded the original, ten-year reduction goal for the program) illustrates the importance of setting targets based on accurate historical data and including mechanisms to adjust the cap if high emissions forecasts prove to be inaccurate.

States could correct for an overinflated cap by retiring allowances that do not sell above the auction reserve price, currently set at $1.86 per allowance. Several states allow for retirement of unsold allowances,[5] but regional coordination of allowance retirement would be needed to adjust each state's allowance supply proportionately. When the program is reviewed in 2012 member states have the opportunity to lock in emissions declines by: 1) reducing the cap level to better reflect actual emissions, and 2) codifying that unsold allowances be retired permanently. Taking these actions would ensure that the cap continues to work as intended by creating incentives for the electric sector to move toward cleaner fuels.

Notes:

- *The mere presence of a cap on emissions has precluded the development of new coal-fired power plants in the RGGI region, which is consistent with the program goal of shifting the region's supply mix toward cleaner fuels.*
- *During program review in 2012, RGGI states should reduce the cap level to reflect actual emissions and require retirement of allowances that do not sell for the auction reserve price.*
- *Draft federal climate legislation allows for cap level adjustment based on latest-available emissions data, and it is imperative that such a mechanism be utilized in order to set an appropriate cap.*
- *Federal legislation should also include a mechanism to reduce the cap level if emissions – and thus prices – are much lower than anticipated, such as an auction reserve price with allowance retirement.*

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[4] Based on an initial assessment by ENE of the first 3 quarters of 2009 emissions data from RGGI, Inc.

[5] RGGI regulations in Delaware, Maine, Maryland, Massachusetts, New Jersey, and Rhode Island allow allowance retirement to varying degrees, while New Hampshire requires that unsold allowances be offered for sale at subsequent auctions and other states are unclear on the issue.

Governance

Design: Grade (**A**)

Spurred by inaction at the federal level, in 2005 a bipartisan group of governors from Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont came together to sign a Memorandum of Understanding laying out the basic parameters of a regional cap and trade system. Over the next three years the program extended to Massachusetts, Rhode Island and Maryland, and all ten states passed consistent enacting regulations based on a cooperatively-authored Model Rule. States also promoted administrative simplicity by utilizing existing EPA requirements for emissions reporting and monitoring. This voluntary, coordinated action by RGGI member states represents a remarkable achievement, both for the system it created and for proving the political viability of sound climate regulation.

Implementation: Grade (**A**)

RGGI continues to be coordinated by an active group of Commissioners and staff from each of the RGGI states. Some program activities such as allowance tracking, auctions, and market oversight are implemented on behalf of each member state by RGGI, Inc., a non-profit corporation created by the member states. To date, all auctions have been conducted successfully, and emissions and market data has been quickly compiled and publicized by RGGI, Inc. An independent market monitor, Potomac Economics, has certified that auctions and the secondary market have been transparent and free of collusion. All of the tracking and oversight systems – such as the CO_2 Allowance Tracking System (RGGI-COATS) – were developed specifically for the RGGI program, and each has functioned effectively, setting important design precedents for regional and federal cap and trade systems.

Note:

- *The Government Accountability Office has gathered information on RGGI governance to help inform the development of federal climate legislation.*

Conclusion

The development and implementation of RGGI was a bold experiment that has yielded impressive results and important lessons for future cap and trade systems. States deserve significant congratulations for coordinating to create RGGI, and for following through with excellent implementation, particularly around the success of the auction markets – the first public carbon market auctions in North America. The investment of RGGI auction proceeds in high value energy efficiency programs is contributing to a transformation in the electric sector; shifting focus from supply to demand and saving consumers millions of dollars. RGGI created organizational and market structures ranging from emissions tracking to regional auctions to market oversight, setting important technical precedents that will smooth the way for future cap and trade systems. In a positive development, emissions have fallen sharply in the region, a phenomenon consistent with the program's goals. However, the incapacity to adapt the program to measured emissions has exposed one of RGGI's primary design flaws – an overly generous cap without an adjustment mechanism. Overall RGGI has been remarkably successful, both for the change it has promoted throughout the region and the lessons it can provide policy makers crafting similar cap and trade systems.

For further information:

Derek Murrow, Energy & Climate Policy Director, (203) 285-1946, dmurrow@env-ne.org
Peter Shattuck, Carbon Market Policy Analyst, (617) 742-0054, pshattuck@env-ne.org

policy

The European Union's Emissions Trading System in perspective

A. Denny Ellerman
Paul L. Joskow
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PEW CENTER ON Global CLIMATE CHANGE

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EXHIBIT 4

The **European Union's** **Emissions Trading System** in perspective

Prepared for the Pew Center on Global Climate Change

by

A. Denny Ellerman
Paul L. Joskow
Massachusetts Institute
of Technology

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Foreword *Eileen Claussen, President, Pew Center on Global Climate Change*

To meet its obligations to reduce greenhouse gas (GHG) concentrations under the Kyoto Protocol, the European Union (EU) established the first cap-and-trade system for carbon dioxide emissions in the world starting in 2005. Proposed in October 2001, the EU's Emissions Trading System (EU ETS) was up and running just over three years later. The first three-year trading period (2005-2007)—a trial period before Kyoto's obligations began—is now complete and, not surprisingly, has been heavily scrutinized. This report examines the development, structure, and performance of the EU-ETS to date, and provides insightful analysis regarding the controversies and lessons emerging from the initial trial phase.

Recognizing their lack of experience with cap and trade and the need to build knowledge and program architecture, EU leaders began by covering only one gas (carbon dioxide) and a limited number of sectors. Once the infrastructure was in place, other GHGs and sectors could be included in subsequent phases of the program, when more significant emissions reductions were needed. As authors Denny Ellerman and Paul Joskow describe, the system has so far worked as it was envisioned—a European-wide carbon price was established, businesses began incorporating this price into their decision-making, and the market infrastructure for a multi-national trading program is now in place. Moreover, despite the condensed time period of the trial phase, some reductions in emissions from the covered sectors were realized.

The development of the EU-ETS has not, however, proceeded without its challenges. The authors explain some of the controversies regarding the early performance of the EU-ETS and describe potential remedies planned for later compliance periods:

- Due to a lack of accurate data in advance of the program, allowances to emitters were overallocated. Now with more accurate emissions data and a centralized cap-setting and reporting process, the emissions cap should be sufficiently binding;

- Concerns about program volatility emerged when initially high allowances prices (driven largely by high global energy costs) dropped precipitously in April 2006 upon the release of more accurate, verified emissions data. Late in the trial phase, there was another sharp decline in allowance price because there were no provisions for banking emissions reductions for use in the second phase of the program. Improved data quality and provisions for unrestricted banking between compliance periods will help moderate price fluctuations in the future;

- Windfall profits by electric power generators that passed along costs (based on market value) of their freely issued allowances resulted in improved understanding of how member country electricity sector regulations affect the market and calls for increased auctioning in subsequent phases of the program.

Interest in developing a national cap-and-trade program in the United States has intensified in recent years. The first comprehensive greenhouse gas reduction bill ever to be reported out of a committee emerged from the Senate Environment and Public Works Committee in December 2007. As debate continues on this landmark legislation, the House of Representatives has signaled its intention to design its own emissions trading program. This report provides an excellent resource for those developing U.S. proposals. As Europe's experience with the EU-ETS suggests, everything does not have to be perfect at the outset of a cap-and-trade program. We do, however, need to get started and, for this, the EU-ETS has provided valuable lessons for us all.

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Executive Summary

The performance of the European Union's Emissions Trading System (EU ETS) to date cannot be evaluated without recognizing that the first three years from 2005 through 2007 constituted a "trial" period and understanding what this trial period was supposed to accomplish. Its primary goal was to develop the infrastructure and to provide the experience that would enable the successful use of a cap-and-trade system to limit European GHG emissions during a second trading period, 2008-12, corresponding to the first commitment period of the Kyoto Protocol. The trial period was a rehearsal for the later more serious engagement and it was never intended to achieve significant reductions in CO_2 emissions in only three years. In light of the speed with which the program was developed, the many sovereign countries involved, the need to develop the necessary data, information dissemination, compliance and market institutions, and the lack of extensive experience with emissions trading in Europe, we think that the system has performed surprisingly well.

Although there have been plenty of rough edges, a transparent and widely accepted price for tradable CO_2 emission allowances emerged by January 1, 2005, a functioning market for allowances has developed quickly and effortlessly without any prodding by the Commission or member state governments, the cap-and-trade infrastructure of market institutions, registries, monitoring, reporting and verification is in place, and a significant segment of European industry is incorporating the price of CO_2 emissions into their daily production decisions.

The development of the EU ETS and the experience with the trial period provides a number of useful lessons for the U.S. and other countries.

- Suppliers quickly factor the price of emissions allowances into their pricing and output behavior.

- Liquid bilateral markets and public allowance exchanges emerge rapidly and the "law of one price" for allowances with the same attributes prevails.

- The development of efficient allowance markets is facilitated by the frequent dissemination of information about emissions and allowance utilization.

• Allowance price volatility can be dampened by including allowance banking and borrowing and by allocating allowances for longer trading periods.

• The redistributive aspects of the allocation process can be handled without distorting abatement efficiency or competition despite the significant political maneuvering over allowance allocations. However, allocations that are tied to future emissions through investment and closure decisions can distort behavior.

• The interaction between allowance allocation, allowance markets, and the unsettled state of electricity sector liberalization and regulation must be confronted as part of program design to avoid mistakes and unintended consequences. This will be especially important in the U.S. where 50 percent of the electricity is generated with coal.

The EU ETS provides a useful perspective on the problems to be faced in constructing a global GHG emission trading system. In imagining a multinational system, it seems clear that participating nations will retain significant discretion in deciding tradable national emission caps albeit with some negotiation; separate national registries will be maintained with some arrangement for international transfers; and monitoring, reporting and verification procedures will be administered nationally although necessarily subject to some common standard. All of these issues have had to be addressed in the trial period and they continue to present challenges to European policy makers.

The deeper significance of the trial period of the EU ETS may be its explicit status as a work in progress. As such, it is emblematic of all climate change programs, which will surely be changed over the long horizon during which they will remain effective. The trial period demonstrates that everything does not need to be perfect at the beginning. In fact, it provides a reminder that the best can be the enemy of the good. This admonition is especially applicable in an imperfect world where the income and wealth effects of proposed actions are significant and sovereign nations of widely varying economic circumstance and institutional development are involved. The initial challenge is simply to establish a system that will demonstrate the societal decision that GHG emissions shall have a price and to provide the signal of what constitutes appropriate short-term and long-term measures to limit GHG emissions. In this, the EU has done more with the ETS, despite all its faults, than any other nation or set of nations.

I. Introduction

A. Motivation

As the world's first cap-and-trade program for carbon dioxide (CO_2) emissions, the European Union's Emissions Trading System (EU ETS) has attracted a lot of attention, some of it favorable and some of it unfavorable. Based on what can be observed to date, this paper attempts to place the EU ETS in perspective for the observer who is interested in understanding the key features and performance of this important public policy experiment. In the following sections, we describe the principal design features of the EU ETS; we highlight two contextual features that are important in understanding the development of the EU ETS; we provide a brief evaluation of the performance of the EU ETS to date; and finally we discuss several of the controversies that have arisen during its first three years of operation.

B. Description of the EU ETS

The EU ETS was inspired by the Kyoto Protocol but it is also independent of it. The EU ETS would not exist if it were not for the Kyoto Protocol and it is the "flagship measure" by which the member states of the EU will meet their obligations under the Kyoto Protocol during the first commitment period from 2008 through 2012 (Delbeke (ed.), 2006). Yet, the EU ETS exists independently of the Kyoto Protocol. It was enacted before the Kyoto Protocol became legally binding in international and EU law and it would have become operational even if the Kyoto Protocol had not entered into force in February 2005. In particular, the trial or first trading period from 2005 through 2007 was wholly outside of the Kyoto Protocol, although conceived as a means of ensuring the EU's compliance with the Kyoto Protocol during 2008-12, when the second trading period of the EU ETS would occur. Finally, the EU ETS is expected to continue beyond 2012 whatever the shape of the Kyoto Protocol or a successor agreement as concerns the post-2012 period.

The EU ETS is a classic cap-and-trade system. However, it also contains some significant design differences from those reflected in cap-and-trade systems for other emissions that have been implemented in the U.S. The common features are that 1) an absolute quantity limit (or cap) on CO_2

emissions has been placed on some 12,000 emitting facilities located in the European Union, 2) tradable allowances have been distributed to these facilities (typically for free) in an amount equal to the cap, and 3) these facilities must measure and report their CO_2 emissions and subsequently surrender an allowance for every ton of CO_2 they emit during annual compliance periods. The primary differences from U.S. experience with cap-and-trade mechanisms relate to how the cap is set, the process for allocating emission allowances, banking and borrowing provisions, the monitoring, reporting, and verification procedures, and the linking or off-system provisions.

While the basic outline of the EU ETS was established during the trial period, significant changes in the design of the system have been proposed by the European Commission in a set of amendments to the Emissions Trading Directive, the authorizing legislation for the EU ETS, which was made public in late January 2008. These proposed amendments resulted from a process that was mandated by the Directive, known as the ETS Review, and which was to consider changes to the Directive in light of the first three years' experience. Consultations with stakeholders have been held over the past year and a half and the proposed amendments will now be taken up by the European Parliament and the European Council in the European Union's co-decision process.[1]

The Cap-setting Process

A first important difference between the EU ETS and the classic cap-and-trade model is the decentralized nature by which the cap has been determined. There was no initially determined overall limit; it was the sum of 25 (now 27)[2] separate decisions concerning the total number of European Union Allowances (EUAs) that each member state could distribute to affected installations within its jurisdiction. Each member state proposed a quantity of EUAs, but that quantity was subject to review and approval by the European Commission according to procedures and criteria specified in the EU Emissions Trading Directive.

A second significant difference is that the long-term trajectory of the overall cap and of the member state allocations was not known initially since the decentralized cap-setting process is repeated for relatively short sequential multi-year "trading periods." The EU ETS Directive mandates a first, three-year trading period for 2005-07, often called the pilot or trial phase, to be followed by a second, five-year trading period for 2008-12 that corresponds to the First Commitment Period under the Kyoto Protocol, and subsequent post-2012 trading periods. The cap for the first period was determined in mid-2005 and the 2008-12 cap was not finalized until late 2007, just before the second trading period began. For the period after 2012, the European Council has declared that the EU's greenhouse gas (GHG) emissions will be at least 20 percent lower than the 1990 level by 2020.[3] This goal has been translated into more concrete terms in the recently released amendments which propose that the next trading period be eight years long, from 2013 through 2020, and that the annual cap for the EU ETS will decline indefinitely at an annual rate of 1.74 percent.[4]

A third difference of the EU ETS is that it is a cap within a cap from 2008 on. The Kyoto Protocol, as modified for the EU15 by the Burden Sharing Agreement (BSA)[5] imposes an economy-wide cap on all greenhouse gas emissions.[6] The EU ETS includes only CO_2 emissions and only a subset of the economy—the power sector, specified industrial sectors,[7] and all combustion facilities with a thermal input of greater than 20 MW regardless of the sector in which they are found (including commercial and institutional establishments).[8] The sectors included under the EU ETS comprise about half of EU CO_2 emissions and about 40 percent of the GHG emissions covered by the Kyoto Protocol. GHG emissions from sources not included in the EU ETS, notably transportation and buildings, are to be limited by other policies and measures. The Emissions Trading Directive anticipates the inclusion of other GHGs and other activities in an expanded EU ETS in subsequent periods and a proposal to include CO_2 emissions from aviation beginning in 2011 is expected to be approved in the course of 2008.

Temporal Trading: Banking and Borrowing

Another notable feature of the EU ETS is that effectively there is no restriction on banking or borrowing of allowances *within any given multi-year trading period*. Allowances are issued annually but they are valid for covering emissions in any year within the trading period. Moreover, each year's issuance of allowances occurs at the end of February, two months before allowances must be surrendered for the preceding year. As a consequence, installations can cover shortages in any given year by allowances issued for the next year. This arrangement effectively allows year-ahead borrowing within the trading period.

The rules governing trading *between* trading periods are, however, more complicated. Most importantly, no banking or borrowing was allowed between the first (2005-2007) and second (2008-2012) trading periods.[9] This limitation effectively made the trial period self-contained and it is one of the major design flaws of the trial period. However, the reason it was adopted is understandable: to prevent any compliance failures during the trial period from spilling over into the second trading period and thereby complicating the attainment of the EU's commitments under the Kyoto Protocol. For the second and subsequent trading periods, unrestricted *inter*-period banking, but not borrowing, will be allowed.

The Linking Directive

An important but less noticed complement to the Emissions Trading Directive is the Linking Directive, which was formally adopted in November 2004. Up to a certain limit, it allows affected installations to comply by submitting qualifying credits for emission reductions accomplished outside of the European Union. The only credits allowed are those created through the provisions of the Kyoto Protocol relating to the Clean Development Mechanism (CDM) or Joint Implementation (JI) and known respectively as Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs).[10] Even so, credits generated by certain CDM activities cannot be used for compliance in the EU ETS, namely, those associated with nuclear power and from CO_2 sinks. Interestingly, however, credits generated by non-CO_2 GHG emission reduction projects outside the EU are acceptable.

The use of these credits by EU ETS installations for meeting compliance requirements is limited to be consistent with the supplementarity criterion of the Kyoto Protocol. This criterion aims at ensuring that a significant proportion of the expected reduction of emissions occurs within each country. While no specific limit is specified in the Kyoto Protocol, this criterion is generally understood to imply that at least half of the reduction implied by the country's assigned limit must be accomplished domestically. In the case of the EU ETS, this limit on CER and ERU use is specified as a percentage of the allocation to an installation for most member states.[11] Thus, if an installation's allocation were 100, its emissions 115, and the limit on CER/ERU use 10 percent, it could use only 10 CERs or ERU's for compliance. The remaining 105 allowances must be EUAs. This limit is specified in each member state's National Allocation Plan (NAP) and it varies among member states and, in some cases, even by sectors within a member state.

While the Linking Directive concerns only project-based credits, the ETS Directive anticipates future links with other compatible cap-and-trade systems whereby the allowances from the two systems would be interchangeable without limit. Moreover, the pre-existing Agreement with the European Economic Area (Norway, Iceland, and Liechtenstein) establishes a procedure whereby new Community legislation can become part of the national legislation of these countries. Pursuant to the latter, Norway's pre-existing but now expanded CO_2 cap-and-trade system was effectively linked to the EU ETS as of January 1, 2008.

Allocation, Registries, and Enforcement

The decentralized character of the EU ETS is not limited to cap-setting; it extends to almost all aspects of the system. The distribution of allowances, the operation of the registries for tracking allowances and emissions, and the monitoring, reporting, and verification procedures that underlie enforcement are all responsibilities of each member state, albeit guided by criteria and coordinated by procedures established by the European Commission. In many ways the EU ETS can be seen as 27 largely independent trading systems that have agreed to make their allowances commonly tradable and to adhere to certain common criteria and procedures in order to make the system work.

This coordinated process begins with the development of a National Allocation Plan by each member state for each trading period. In the NAP, the member state proposes and justifies the total number of allowances created for the trading period, provides a list of covered installations, and explains how those allowances are to be distributed. In its review and approval of NAPs for the first and second trading periods, the Commission has been concerned mostly with the level of the proposed member state "caps",[12] with attempting to ensure a consistent definition and inclusion of affected installations, and with prohibiting allocation rules that would inhibit trading, such as ex post adjustments. By and large, member states have been free to allocate to sectors and installations within their jurisdictions as they see fit. While the principles applied in these internal allocations have been remarkably consistent (Ellerman, Buchner and Carraro, 2007), national circumstances have led to considerable differences in the allocations to like facilities in various member states, especially in the power sector. These differences have led in turn to a demand for greater "harmonization" in the allocation of EUAs among the member states.

Each member state also maintains its own registry to record the creation, transfer, and surrender of allowances; however, a high degree of uniformity is maintained through the Registries Regulation (European Commission, 2004b) which applies directly to all member states.[13] Transfers of EUAs among installations located in *different* member states are not only recorded as such in the respective member state registries but also reported to a central registry in Brussels, called the Community Independent

Transaction Log (CITL). By this means, the Commission would be able to block transfers from any member state that fails to gain approval of its National Allocation Plan or is otherwise out of compliance with the EU ETS. Finally, member states report allocations and verified emissions at the installation level to the central registry.

Member states also develop their own monitoring, reporting, and verification procedures subject as always to the EU Monitoring and Reporting Guidelines (European Commission, 2004a). The basic structure is similar to financial reporting by which firms self-report based on pre-specified procedures of measurement and calculation. And, like the financial analogue, these reports must be audited (or verified in emissions trading parlance) by external parties. Emissions are generally not measured directly, but determined by calculation based on fuel consumption, specified emission factors, and the thermal efficiencies for combustion units and on output and other chemical and engineering estimates for process emissions. In order to avoid undue cost, the specific monitoring, reporting, and verification procedures vary according to the size of the installation with higher "tier" or more accurate and more costly techniques being applied to larger installations than to smaller ones. Each member state is responsible for certifying verifiers and more generally for ensuring compliance through the deduction of allowances from accounts in the *national* registry equal to the verified emissions reported for each installation. However, the compliance penalties are specified in the Emissions Trading Directive. This is the only EU law to prescribe financial penalties that must be applied automatically for non-compliance.

II. Context

A fair appraisal of any policy requires an understanding of the conditions under which it was adopted and in which it is implemented. For an American observer, this perspective is especially important because the conditions influencing the creation and operation of the EU ETS are different from what would likely apply to the design and implementation of a cap-and-trade program to control GHG emissions in the United States. Two contextual factors are particularly important: the nature of the trial period and the multi-national character of the European Union.

A. The Trial Period (2005-2007)

The decision to establish a trial period beginning in 2005 compressed the time schedule for the development and implementation of the EU ETS to an almost impossible extent. The rushed result shows that everything need not be perfect, but it also accounts for many of the rough edges that can be observed in the subsequent performance of the EU ETS.

The adoption of a trial period was motivated by the perception of a "performance gap" in the European Union's ability to meet its commitments under the Kyoto Protocol and by a recognition that the institutions and experience needed to successfully implement an EU-wide cap-and-trade program could not be taken for granted. This warm-up phase was expected to provide the experience and establish the infrastructure to ensure success in the "real" mitigation period corresponding to the First Commitment Period under the Kyoto Protocol.

A few years after the negotiation of the Kyoto Protocol, it came to be recognized that more aggressive mitigation actions than had originally been anticipated would be needed if the EU's Kyoto commitments were to be honored. The downward trend in GHG emissions that was experienced in the 1990s had reversed and emissions seemed likely to be considerably above the Kyoto target for the EU15 of minus eight percent in relation to 1990 emission levels. Various policies and measures were being undertaken by member states, but something more was needed at the EU level. An EU-wide CO_2

emissions tax was not possible since one had been proposed and rejected in the 1990s. A cap-and-trade approach was chosen because it guaranteed a limit on a significant part of the EU's emissions, it was compatible with the emissions trading provisions of the Kyoto Protocol (adopted at U.S. insistence, ironically), and it was the only other instrument available.

While a cap-and-trade approach seemed appropriate, it was also recognized that there was virtually no experience with emissions trading in Europe and less familiarity with market-based instruments than in the U.S., where cap-and-trade programs had been successfully implemented. Only the UK and Denmark had conducted limited experiments in emissions trading and there was no precedent for a cap-and-trade system covering more the one country.

A cap-and-trade program was first suggested as an important component of the European Climate Change Programme in a Green Paper issued in March 2000 (European Commission, 2000). This concept paper explained how cap-and-trade mechanisms worked, pointed out important issues that would have to be resolved, and generally discussed what would be involved in the design of an EU CO_2 trading system. A concrete and specific implementing directive was not proposed until October 2001, barely three years before the program was to start. A common reaction at the time was succinctly stated in an editorial in Point Carbon's September 2001 edition of *Carbon Market Analyst*:

> *"We believe that the chance of having a community-wide trading scheme in place by 2005 is a low-probability scenario."*

It took nearly another two years, until the summer of 2003, for the proposed Emissions Trading Directive to wend its way through the EU's co-decision process. The final approval by the Council of Ministers occurred in July 2003, and the Directive was formally issued in October 2003, barely a year before the program was to begin.

An EU Directive is only a framework that has to be given legal force and implementation through a process called transposition, which requires member state governments to issue legislative and regulatory measures to implement the directive within each national jurisdiction. As agreed in July and issued in October, the Emissions Trading Directive called for implementing regulations to be in place by the end of 2003 and for National Allocation Plans to be submitted by the end of March 2004. And, as if this were not enough, ten mostly East European countries acceded as new member states in May 2004 and greatly increased the scope of the scheme, as well as the difficulties of its implementation.

The result was that only five National Allocation Plans were submitted to the European Commission on time and the last member-country's plan, for Greece, was not approved until June 2005, six months *after* the trial period had begun. Moreover, when the trial period started on January 1, 2005 there was only one operating national registry, in Denmark, and it was another year and half before the last of the initial East European registries, in Poland, became operational.

The time taken to develop and implement the relatively complex EU ETS was much less than was the case for the simpler U.S. SO_2 cap-and-trade program. The initial Bush Administration proposal that became the basis of the eventual U.S. legislation was put forward in April 1989, almost seven years before the intended start in 1996. Subsequent changes in Congress moved the start date to 1995, but even so the legislation was voted out of both Houses of Congress and signed by the first President Bush in November 1990, a little more than four years before the program's start. More importantly, the aggregate SO_2 emission cap and the initial allocations had been determined during the legislative process so that attention could focus thereafter on implementing regulations and the development of the registry, all of which were in place when the program started on January 1, 1995.

B. A Multinational System

The multinational character of the EU ETS is a second feature to keep in mind in evaluating its performance from an American perspective. In brief, the European Union is not the United States of Europe. The federal structure of the EU is unique of course, but for an American historical analogy, it has far more in common with the Articles of Confederation than it does with the post-Constitution, post-Civil War United States of America. Member states of the European Union are sovereign nations that have ceded some authority to the central institutions in Brussels, but they retain prerogatives and authority beyond that of any American state. Unlike U.S. states, each has a seat in the United Nations and each maintains its own diplomatic representation abroad. Moreover, the differences in economic circumstance among member states of the EU are considerably greater than those among American states.[14] These underlying political and economic realities cannot fail to be reflected in the EU ETS and they are.

The main point of contention in the relations between Brussels and the individual Member States with respect to the EU ETS has appeared in the negotiation of member state emission caps. Member states have in the main accepted the Commission's decisions, although several have brought legal challenges before the European Court of First Instance. During the allocation process for the trial period, the UK and Germany brought relatively technical law suits concerning whether the UK could revise its total after approval by the Commission and whether Germany could make ex post adjustments to its allocation to facilities in covered sectors. The current allocation process for the second trading period has produced more challenges. Nine Member States, all of the initial East European accession countries except Slovenia, have contested the Commission's significant reduction in the emission caps proposed by these member states. Their primary argument is that the Commission's methodology to determine member state totals is inappropriate to their circumstances either because they are small or that the ongoing structural transformation of their economies has not been properly taken into account. These legal challenges will take three to four years to resolve; in the meantime, all are expected to continue to participate in the EU ETS on the basis of the Commission's decisions[15]

This decentralized cap-setting and allocation process is very different from that in the U.S. SO_2 cap-and-trade system (Ellerman et al., 2000). In the U.S. SO_2 program, the cap and the allocations to affected installations were determined centrally in the Congressional legislation; the registry was maintained at the national level; and affected facilities reported emissions directly to the federal U.S. Environmental Protection Agency (U.S. EPA). The states are invisible in this program except for some allocation provisions in the legislation that provided additional allowances to installations located in certain states.

The NOx Budget Program comes closer to being similar to the EU ETS in structure, although even here there are differences (Aulisi et al., 2005). In this program, the U.S. EPA assigns an emission budget to the state and the state is free to allocate allowances to covered installations within its jurisdiction without further review. Most states have allocated allowances in a manner that is reasonably similar, but there are some striking differences, such as the updating provisions in New Jersey and a few other states, which in European parlance would be deemed ex post adjustment. In the NOx Budget Program, the NOx emissions are reported to the federal level and the federal EPA maintains a separate tracking system or registry for the NOx allowances created by the states. The states are, however, responsible for enforcing compliance, like in the EU ETS, and unlike in the U.S. SO_2 cap-and-trade system.

As noted by Kruger, Oates and Pizer (2007), all of the decentralized aspects of the EU ETS are "problematic." Some have precedents or analogues in American experience with cap-and-trade systems, but most do not. The underlying issue in achieving greater coordination is not so much desirability as it is political feasibility. The decentralized features of the EU ETS are not inherent in cap-and-trade systems as such; but they are the political manifestation of the multinational character of the European Union.

The current highly decentralized structure of the EU ETS will be almost entirely eliminated if the draft amendments to the Emissions Trading Directive recently put forward by the Commission are enacted. The EU-wide cap would be determined centrally; the distribution of allowances within member states would be harmonized by mandatory auctioning for the power sector and a rapid phase out for others; there would be common rules for allocating the residual free allowances; National Allocation Plans would no longer be required, and national registries would be collapsed into the central EU registry. These proposed amendments will provide a good test of whether the political reality within Europe has advanced to embrace this degree of centralization.

III. Performance

The performance of a cap-and-trade system has many dimensions, including: (a) the development of liquid, transparent markets for allowances, (b) the incorporation of allowance prices into business decisions, (c) the impact on covered emissions, (d) the costs of controlling emissions, (e) the relationship between emissions prices and the marginal cost of abatement, and (f) the effectiveness of monitoring and verification protocols. In this section of the paper, we discuss the development of the market for EUAs and the results of the verified emission reports for the years 2005 and 2006, the first two years of the trial period.[16] The behavior of allowance prices and the relationship between emissions and allowance allocations, including the overall EU cap, are the source of many of the controversies concerning the EU ETS. This chapter provides the empirical basis for understanding these controversies and for evaluating the EU ETS during the trial period.

A. The Emergence of a Single Price

A visible single price for a given product is the pre-requisite for an efficient market for a homogenous product without transportation costs. In cap-and-trade systems, a single price leads to least-cost attainment of the emissions constraint since the price provides a common signal to participants of the marginal cost that can be economically justified in reducing emissions and adjusting production.

Figure 1 displays the evolution of price of EUAs since January 1, 2005, when the EU ETS went into effect. The two price series shown are those for the trial period, 2005-07, as represented by the futures contract for delivery in December 2007, and for the second trading period, 2008-12, as represented by the contract for delivery in December 2008. Each of these is a different product because of the absence of banking from the first to the second period.

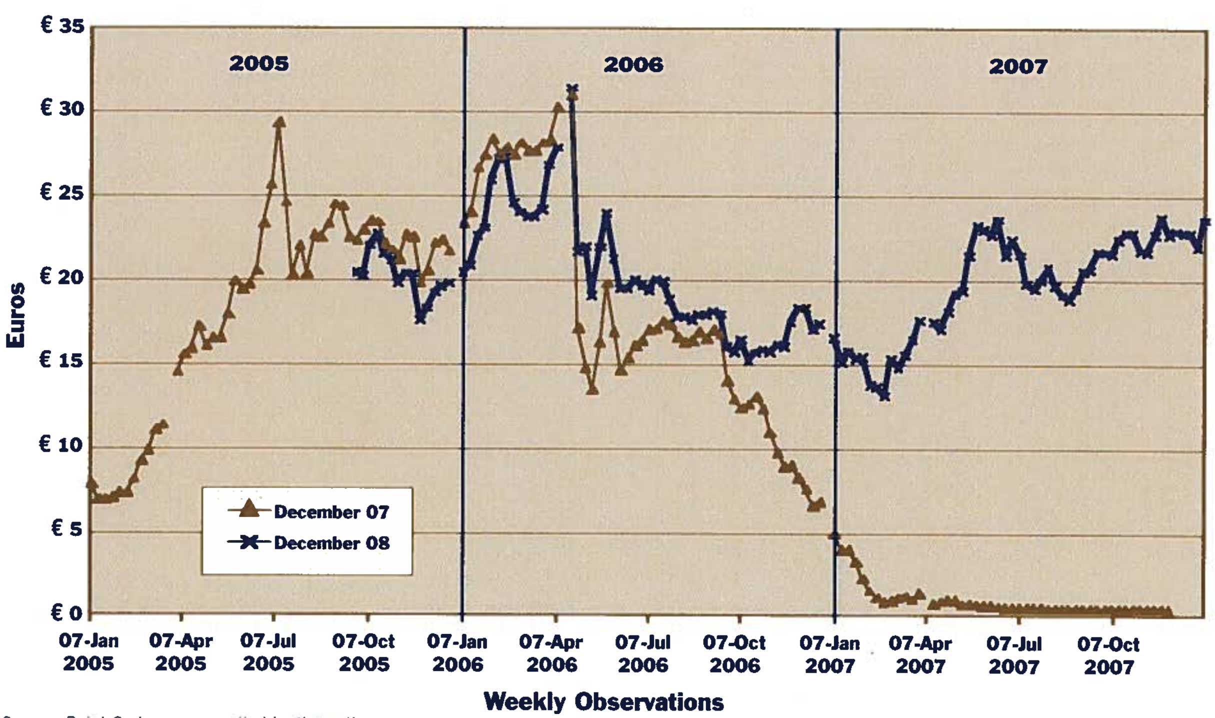
The difference between first and second period prices has been evident since the December 2008 contract was first introduced in September 2005, but it became most significant and sustained after September 2006 when first period prices began their decline toward zero. The extraordinary discount applied to the trial period EUAs from September 2006 on, as well as the premium paid for these same EUAs prior to April 2006, are largely explained by one phenomenon: the restriction on trading between the first and second periods. This restriction effectively made trading during the trial period self-contained and virtually assured that the trial period would be either in surplus or deficit when the final accounting for 2007 emissions is completed and announced in April 2008.[17]

Another salient and much noted feature of the evolution of EUA prices is the sharp decline that occurred in late April 2006 for both trial period and second period EUAs. In the space of less than a week, prices fell from over €30 to about €20 for second period EUAs and to €15 for trial period EUAs. The precipitating event was the reporting of 2005 emissions by several member states in amounts that were significantly less than expected.

The sharp break in pricing at this time reflects a phenomenon that is found in many cap-and-trade programs: initial expectations about prices are often wrong. The problem is not the cap, which is known from the beginning, but expected aggregate emissions, which determines actual demand for allowances.

Figure 1

Evolution of EUA Prices 2005-2007



Source: Point Carbon as compiled by the authors.

The uncertainty concerning the demand for allowances is especially large at the beginning of any program because it reflects not only the usual unpredictable variables of economic activity, weather, and energy prices, but also, and perhaps more importantly, the amount of abatement that will take place in response to the new price on emissions.

The first public release of emissions data provides the means to calibrate expectations with actual demand and prices adjust accordingly. This is what happened in the EU ETS and it happened in the U.S. SO_2 trading system (Ellerman et al., 2000). In both cases, the initial emissions reports revealed lower emissions than expected and the resulting adjustment of expectations reduced the price of allowances significantly, albeit more rapidly in the case of the EU ETS than for the U.S. SO_2 trading system. Once the first emissions reports have provided reliable data to calibrate expectations, later reports have much less if any effect on pricing. For instance, the April 2007 release of verified emissions for 2006 had no effect on EUA prices.

The magnitude of the price adjustment in responding to an initial calibration and the speed with which it occurs depend on the frequency of the releases of emissions data and the length of time over which adjustments in demand (i.e., emissions) can occur. When the data releases are frequent and the adjustment period long, the adjustment in the level of emissions can be spread over a longer period of time and the immediate price effect will be smaller. However, when horizons are truncated, as is the case for the first period of the EU ETS, the adjustment period is shorter and the immediate price effect will be greater. For the EU ETS, the sharp price decline in April 2006 reflected both the annual data reporting and the self-contained three-year trading period. Almost half the period had elapsed before expectations could be calibrated and adjustments in emissions could occur.

The effect of the truncated horizon can be observed in the different response of first and second period EUA prices to the revelation of information in April 2006 and in the subsequent evolution of those prices. When the adjustment took place, first period prices dropped by 50 percent and second period prices fell by 33 percent. The prices for both periods were affected because for the first time there was reliable information concerning the magnitude of aggregate covered emissions and the associated demand for allowances. The first period price fell farther because of the relatively short time remaining in the period to work off the unexpected surplus. As the trial period proceeded towards its conclusion and the remaining uncertainties were resolved, the price for first period allowances fell slowly but steadily from over 15 euros in September 2006 to zero in March 2007. In contrast, the second period price has remained in the vicinity of €20 since late 2005 and has provided a relatively stable signal to participants concerning the expected value of emission reductions in 2008-12.

B. Why EUA Prices Were So High and Then So Low

During the first half of the trial period, the dominant question among market analysts was: Why are prices so high? Prices had been expected to be between €8 and €12 and they had started out within that range when the program got underway in January 2005. However, as can be seen in Figure 1, prices climbed rapidly over the next five months to €20 and they stayed at or above this level until the release of the 2005 verified emissions data in April 2006. The explanations at the time for the higher than expected prices in 2005 and early 2006 cited fundamental factors: a cold late winter in early 2005, a dry summer in southern Europe, and high natural gas and oil prices that made coal more attractive. A not uncommon reference was to the switching price, the CO_2 price level at which switching generation from a representative coal-fired unit to representative natural gas-fired unit in the power sector would be profitable. This switching price was always higher than the observed EUA price and that fact sustained a belief of strong demand for EUAs and a possible shortage of trial period allowances. An example of this frame of mind was the headline of the front-page guest editorial in Point Carbon's April 21 edition of *Carbon Market Europe*, which affirmed on the eve of the price collapse: "CO_2 price still too low."[18]

In retrospect, it is evident that another factor was at work in propelling EUA prices to these high levels and maintaining them there: an institutionally caused imbalance in the presence of buyers and sellers in the EUA market. In brief, companies with installations that were short allowances and needed to cover their emissions were disproportionately present and the companies that held long positions were not as active in the market.

The companies that were short were almost entirely electric power generators located in the EU15. They were short as a result of an explicit policy decision taken by many EU15 governments to allocate the expected member-state gap between business-as-usual emissions and EUAs to the electric power generating sector. The rationale for doing so was (a) that electric utilities had more means of abatement available in the short run than did other industries (e.g. switching from coal to gas) and (b) that they did not face international competition with countries outside of the EU. Adding to the buying pressure was the hedging demand of electric utilities with respect to the carbon liabilities implicit in forward power contracts. In 2005 and early 2006, this meant increased demand for first period allowances at a time when potential sellers were not as active.

The potential sellers—non-power companies in the EU15 and all companies in Eastern Europe—were largely absent from the market for several reasons. First, installations with a long position are under no compulsion to sell to the market, unlike companies with short positions who must acquire allowances to cover emissions for the current year. Companies with a long position can take a wait-and-see attitude and many appear to have done so. Many were small firms not inclined to trade in the market anyway or were located in Eastern Europe where, even if they wished to sell, the registries necessary to deliver EUAs to buyers were not yet in place.

These factors changed in 2006 and explain the behavior of prices during the last half of the trial period. All the registries and other trading institutions were in place and operating well. Companies who were long in their allowance positions, and who kept their extra allowances for possible later use, came to realize that their first period needs were covered and that selling allowances that could not be used in the second period for a low price was better than getting no sales revenue at all. Finally, trial period EUAs were useless to power companies seeking to hedge 2008 forward electricity contracts. Thus, as 2007 approached and progressed, additional supplies of emissions allowances were released to the market at the same time that the demand for first period allowances by electric generating companies declined.

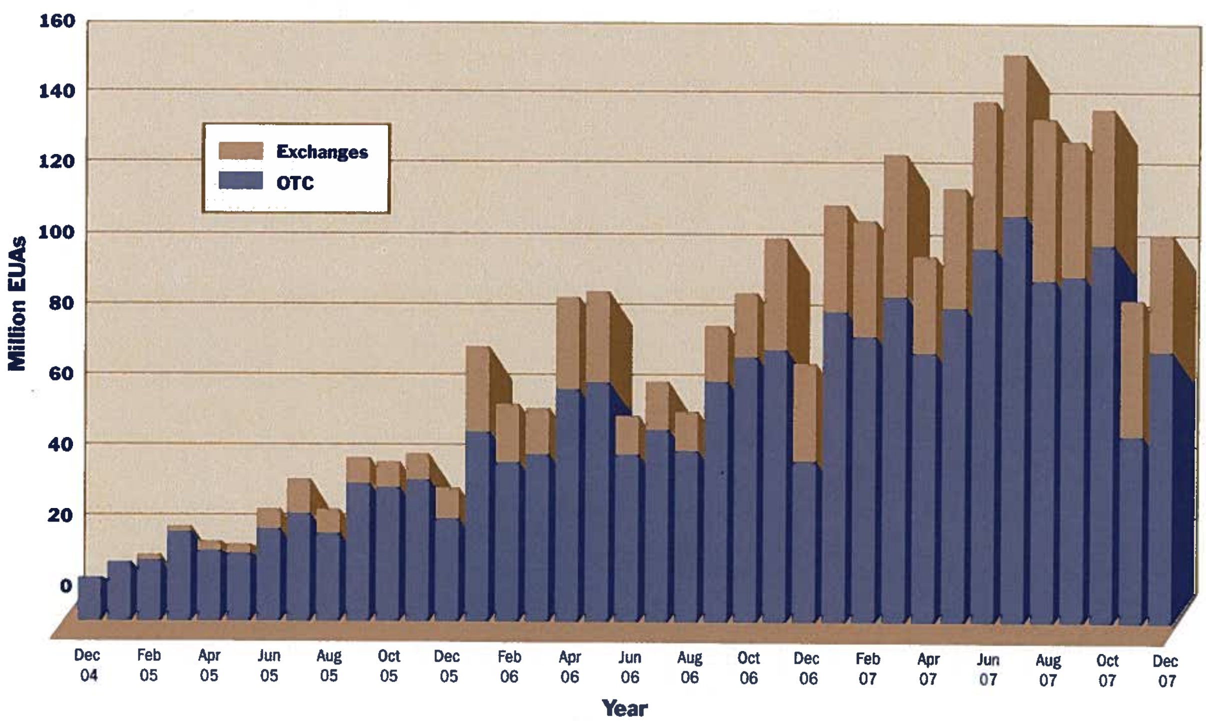
C. The Volume and Types of Trading

Although prices are certainly the most visible manifestation of a market, other attributes of markets and market institutions, such as trading volume, the nature of allowance contracts, and the development of efficient trading platforms, are also important. These attributes facilitate efficient abatement and product sales strategies by companies with affected facilities. As has been the case with allowance markets in the U.S., the volume of trading in the EU ETS has grown steadily as the program got underway. Figure 2 shows the steady increase in trading volume from a monthly average of about 10 million EUAs in the first quarter of 2005 to around 100 million from the first quarter of 2007 on.

An important feature of the EUA market that distinguishes it from U.S. allowance markets is the importance of organized exchanges. Over-the-counter markets, which account for virtually all U.S. allowance trading volume, were the first type of EUA trading platform to appear and they remain the dominant form of trading. Trading on organized exchanges appeared early and grew rapidly to where now about one-third of trades take place on exchanges.[19] The first trading on an organized exchange, Nordpool, occurred in February 2005, but by June of that year, four more exchanges had opened in Leipzig, London, Paris, and Vienna. These exchanges do not all trade in the same instruments. The London Exchange, ECX, offers futures, options, and swaps, while the Paris exchange, Powernext (now Bluenext), started out offering only a spot contract. Each of the other exchanges offers some combination of spot, forward, and futures contracts. The ECX is now by far the largest single platform for trading and it accounts for about 75 percent of the exchange volume. The appearance and continuance of these exchanges provides further evidence that the law of one price emerged early in the EUA market because exchanges could not operate if there were no convergence of prices.

Figure 2

Monthly EUA **Trading Volumes** 2005-2007



Source: Point Carbon and Mission Climat of the French Caisse des Dépôts.

The main trading instruments in the EUA market are forward and futures contracts for delivery in December of the specified year. The December maturity for each year is a convention that conforms to the reconciliation procedures in the EU ETS. Companies must surrender allowances equal to their emissions by the end of April in the following year. Thus, a firm that needs to purchase EUAs to cover emissions or that wishes to hedge its exposure for current production can either purchase the required EUAs in the spot market or purchase a futures contract corresponding to the compliance year for which allowances will be surrendered.

The EUA market has exhibited the same characteristics as markets for tradable permits in the U.S., such as those for SO_2 and NOx. Notably, a market developed relatively quickly without special effort on the part of the government beyond creating the scarcity, distributing the permits, and enforcing compliance. In all cases, there has been no lack of intermediaries to facilitate trading among parties with either long or short positions and to create a single price at any one moment in time for trading instruments with similar attributes. Whether all participants in the EU ETS have taken advantage of that single price to optimize abatement is another question, but there can be no doubt that the pre-requisite is present.

D. Emissions and Allowances: 2005-2006 Results

Market data do not provide information about the actual transfers of EUAs between buyers and sellers for compliance purposes. The activity observed in commodity markets is often motivated more by financial considerations than it is by needs for compliance trading. Financial transactions reflect the desire of emissions sources to hedge their positions as well as the activities of traders taking the other side of these hedges or otherwise speculating on movements in market prices. These transactions involve futures contracts for which many if not most of the positions taken are liquidated prior to their maturity thereby avoiding any physical delivery. Trading for purposes of compliance will always be a part of observed trading but it can be a small part. For evidence of compliance trading, the data on annual allowance allocations and verified emissions published annually in the Community Independent Transaction Log (CITL) must be consulted.

Installations with a net short position must either acquire EUAs from some other installation typically through the market or borrow from its allocation for the

Table 1

EU25 Allowance and Verified Emission Totals 2005-06

	2005	2006
One-third of 3-yr total	2,183	2,183
CITL Allowance Allocations	2,091	2,067
CITL Verified Emissions	2,010	2,028
CITL Indicated Net Long	81	39

Source: Community Independent Transaction Log (as of July 20, 2007).

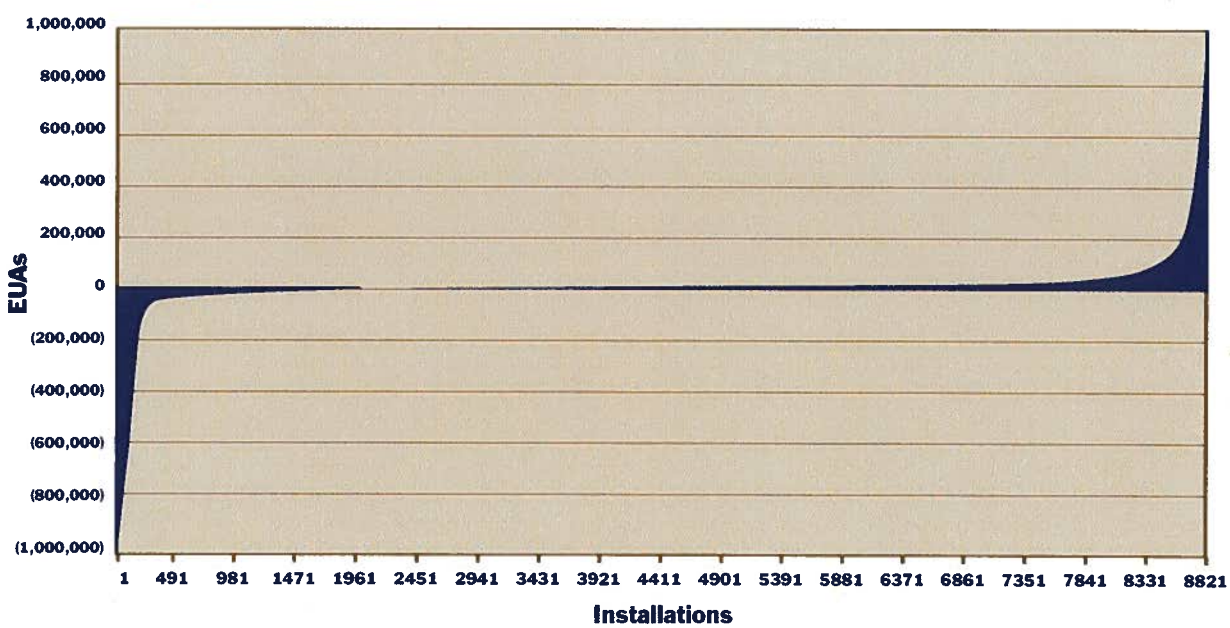
next year. In sum, each such installation is a potential buyer. Conversely, every installation with a net long position is a potential seller. In the aggregate, the EU ETS has been long for both 2005 and 2006. The total number of allowances created for the EU25 for the first trading period is approximately 6.55 billion, which implies an annual distribution of about 2.18 billion. Table 1 reports the aggregate allowance and emissions position of the EU ETS as a whole.

The number of allowances allocated to installations in the CITL is fewer than one-third of the three year total because of allowances held back for auctions and new entrant reserves. As a result, the net long position as shown in the CITL is less than the true long position. Verified emissions will almost surely be greater in 2007 than in 2006, and perhaps show a short position in the CITL; however, as indicated by the evolution of EUA prices toward zero, no one expects the likely increase of emissions in 2007 to create a shortage for the period as a whole.

A net long position for the trial period as a whole does not imply that every installation, member state or sector has a long position. Figure 3 presents the distribution of net physical positions by installation in 2006, truncated at plus and minus one million. The 2005 distribution is similar.[20]

Figure 3

Distribution of **EU ETS Installations** by Net Positions in 2006



Source: CITL

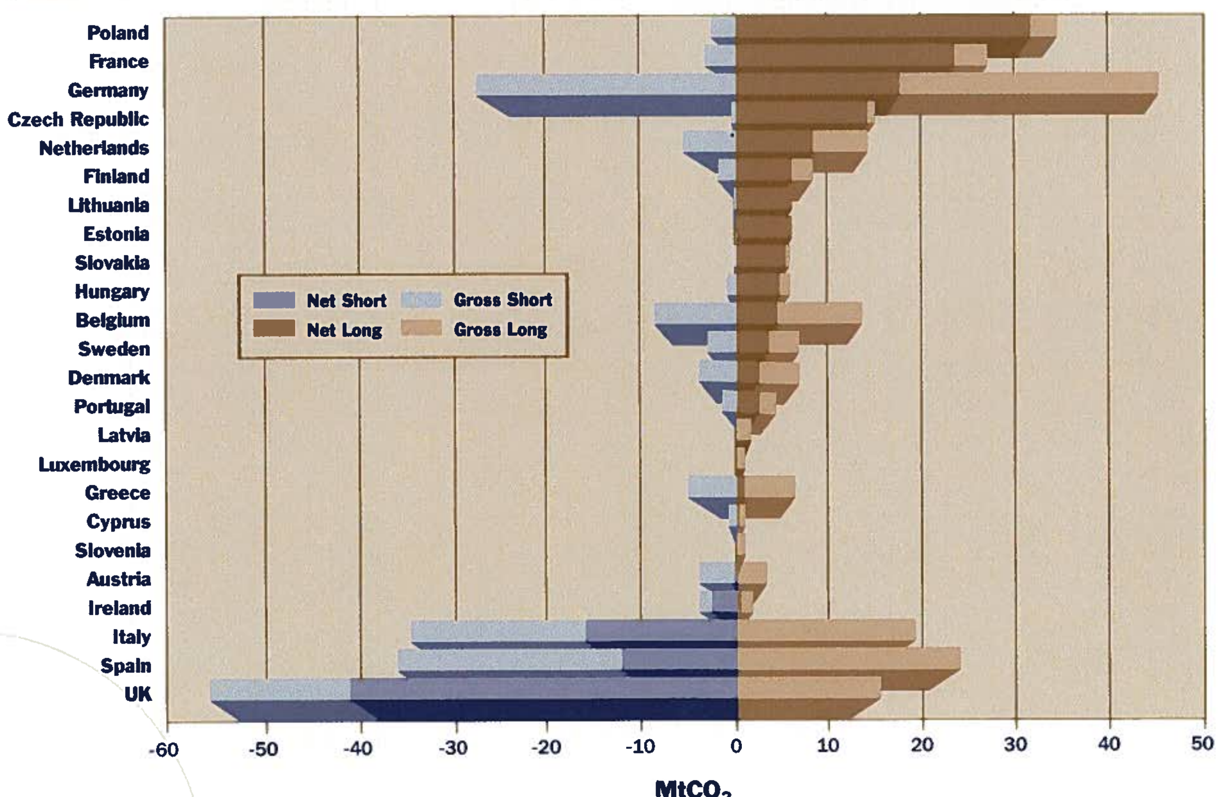
As can be readily seen, the bulk of the physical market resides in the tails. Fully two-thirds of the 9000+ installations depicted in this graph have surpluses or deficits smaller than 10,000 EUAs and less than 1 in 9 had a net physical position greater than 50,000 EUAs, approximately 300 of which were on the minus side and 700 on the plus side. The net short or long positions for individual installation could be very large. The largest long positions were 6.2 million and 5.2 million in 2005 and 2006, respectively, and the largest short positions were 6.2 million and 8.2 million in the same years.

When aggregated at the member state and sector levels, there is also considerable heterogeneity. Figure 4 shows the average member state position for the first two years of the trial period.

The light colored bars in Figure 4, labeled gross long and gross short, represent the sum of all the installations with net long and short positions in that member state; and the darker portion of the bar, denoted as net long or net short, indicates the net position of the member state. These darker portions of each bar indicate the potential for transfers of allowances among the member states. For example, in

Figure 4

Distribution of Long and Short Positions by Member State 2005-2006



Source: Ellerman and Buchner (2008) based on the CITL.

Great Britain, the sum of all short positions averaged almost 56 million EUAs for these two years and the sum of the long positions at UK installations was about 15 million EUAs. Although some of the surplus positions may have been sold or transferred to installations outside the UK, the net annual demand for allowances from other member states by installations in the UK was about 41 million EUAs.

It can be easily seen that the bulk of the physical demand (95 percent) for EUAs from individual member states came from the UK, Italy, and Spain and that the largest but by no means only potential suppliers were Poland, France, Germany, and the Czech Republic, which together accounted for 64 percent of the total net long positions. Of the other 17 member states, two are in net short positions, Ireland and Austria, and the remaining 15 are in net long positions.

The registry data for individual installations also indicate that the extent of compliance trading is significant and the patterns of trade diverse. Table 2 on page 22 presents these patterns for two large power plants in the UK for 2005 and 2006.

Drax is the largest coal-fired power plant in the United Kingdom and it was short by significant amounts: 6.2 million allowances in 2005 and 8.0 million in 2006. As indicated by the last three rows, slightly more than a quarter of its short position was covered by EUAs originating in the UK in both years and the remaining EUAs were acquired from abroad, presumably by purchase. However, the sources of this supply shifted significantly between the two years from the EU15 to the new member states.

Ferrybridge is another coal-fired power station in the UK, somewhat smaller than Drax, but also significantly short in both years. Its compliance strategy differed markedly from that of Drax. In 2005, it covered all of its short position by EUAs originating in the UK, but in 2006 only a small fraction of its entire surrender requirement originated from within the UK. The registry data do not allow analysts to determine whether the UK allowances surrendered in excess of the installation's allocation for 2005 were bought from UK installations or borrowed from Ferrybridge's 2006 allocation. However, the dramatic reversal the next year, is consistent with "borrowing" its 2006 allocation to cover 2005 emissions and then making up the difference by later purchases. Most installations don't reveal this pattern and it would not normally be observed unless the operator believed that future prices would be lower and was willing to "short" the next year's allocation. If this was the case at Ferrybridge, it was a profitable strategy since it avoided a large cash outlay when EUA prices were very high and allowed the "short sale" to be covered when prices were lower.

While only illustrative, these two installations show that the flexibility available through emissions trading is being used by participants in the EU ETS. Allowances were acquired by these two plants alone from 22 of the 25 member states (excepting only Slovenia, Cyprus and Malta). It is also readily seen that Eastern Europe became a significantly larger seller in 2006 than in 2005 in part due to the delayed development and approval of registries in those member states. Finally, the behavior of Ferrybridge suggests that borrowing against the next year's allocation is done and that it can prove profitable for those willing to take the risk of the allowance equivalent of shorting the next year's allocation.

Table 2

Illustrations of Compliance Trading for Two UK Plants (thousand EUAs)

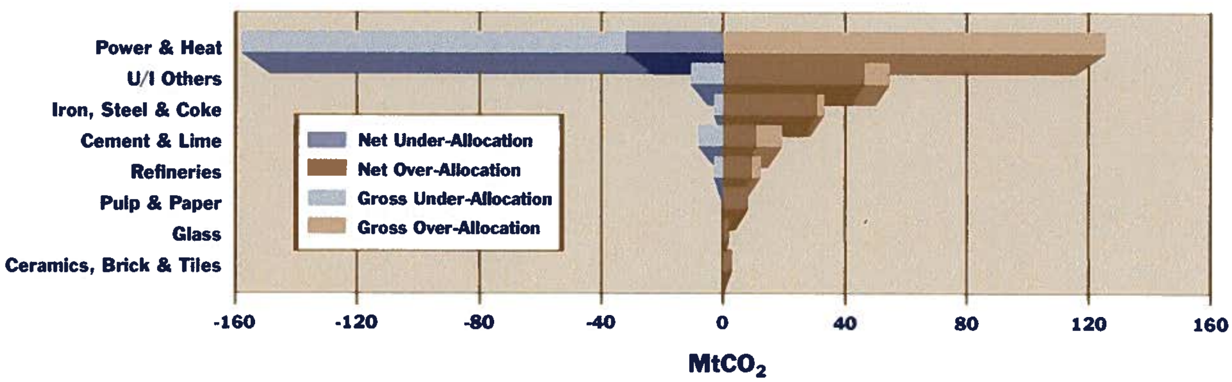
Originating Registry of Allowances Surrendered	Drax		Ferrybridge	
	2005	2006	2005	2006
United Kingdom	16,258	16,683	8,413	201
Austria	14	25	—	37
Belgium	601	5	—	—
Czech Republic	675	130	—	257
Germany	963	236	—	705
Denmark	224	236	—	293
Estonia	895	2,740	—	627
Spain	5	511	—	—
Finland	238	26	—	373
France	485	541	—	875
Greece	—	50	—	779
Hungary	—	187	—	538
Ireland	3	30	—	—
Italy	—	41	—	85
Latvia	80	76	—	103
Lithuania	—	—	—	1,085
Luxembourg	—	—	—	100
Netherlands	206	458	—	402
Poland	—	341	—	643
Portugal	—	87	—	273
Sweden	18	32	—	250
Slovakia	87	82	—	1,159
Total EUAs Surrendered	20,772	22,516	8,413	8,784
EUAs Allocated	14,554	14,554	4,785	4,785
Net Short Position	6,217	7,962	3,628	3,999
From the UK[a]	1,704 (27%)	2,129 (27%)	3,628 (100%)	–4,584 (–115%)
From other EU15	2,777 (45%)	2,190 (28%)	0	4,171 (104%)
From New Member States	1,737 (28%)	3,643 (45%)	0	4,412 (110%)

Source: CITL, as compiled by the authors.
Notes: a. After deduction of allocated allowances.

The individual installation data can also be aggregated by sectors as is done in Figure 5. The imbalance between supply and demand by sectors is readily evident. Virtually all of the demand for allowances to cover emissions comes from the power and heat sector, which is mostly the generation of electricity. The supply side is more balanced with nearly half of the potential supply coming from installations in the power and heat sector that are long and the other half from the remaining non-power sectors. This imbalance in the distribution of long and short positions by sector reflects more the decision of many EU15 member states to allocate the expected shortage to the power sector than it does any failure to abate by that sector or greater willingness to reduce emissions by the non-power sectors. The decision to assign the shortage to the power sector was not consistent across member states, but when done, it created significant short positions for many power companies.

Figure 5

Distribution of Long and Short Positions by Sectors 2005-2006



Source: CITL, Ellerman and Buchner (2008)
Note: "U/I Others" includes installations for which the sector could not be identified and combustion installations in other sectors.

IV. Controversies

The EU ETS did not arouse nearly as much public controversy when the Directive was being debated as it did once it went into effect. During its development, it was seen as one of several measures to achieve a goal that had broad public support, the fulfillment of the EU's obligations under the Kyoto Protocol. However, it was not long after January 1, 2005, that the program became the object of highly vocal public criticism.

Most of the criticism has focused on two issues: "windfall profits" and "over-allocation." The former refers to the higher electricity prices and consequent higher corporate profits that resulted from the free allocation of allowances and the latter implies an emissions cap that was not sufficiently constraining or at least not demanding enough. These two main critiques are somewhat inconsistent as concerns electricity prices. The "windfall profits" critique is motivated in large part by a concern about the effects of higher electricity prices, and suggests that electricity prices would have been lower but for the passing through of the market value of freely allocated allowances. At the same time, the "over-allocation" critique asserts that the cap was too lax and implies that it should have been tighter, which implies a higher CO_2 price and consequent higher electricity prices.

Surrounding these two main critiques are others concerning the allocation process, the volatility of EUA prices, and the linkage provisions. In this chapter, we seek to explain these controversies. In many respects, these controversies reflect either a misunderstanding of how cap-and-trade systems work in a market economy or fundamental disagreement with basic provisions of the EU ETS.

A. Windfall Profits

The windfall profits critique is focused almost exclusively on wholesale electricity prices and real or imagined additional profits earned by some electric generators to which allowances were allocated for free. Critics point to rising wholesale power prices during the first half of the trial period and allege that power supply bids "improperly" included the market value of freely allocated allowances, instead of their zero cost, into power supply bids thereby causing higher wholesale power prices and significantly higher profits for some generators. The proposed remedy has usually been for the government to auction the allowances instead of allocating them for free. As usually presented, the windfall profits critique glosses over a number of contextual, conceptual and empirical difficulties.

Context: An Electricity Sector in Transition

During the time when the EU ETS was being designed and implemented, the European Union was also proposing and adopting various policies to "liberalize" wholesale and retail electricity markets. The long-term goal was to achieve deregulated competitive wholesale and retail markets in which electric generators and retailers would compete to meet the needs of residential, commercial and industrial consumers.

Freely allocated allowances will have a very different effect on electricity prices depending on the degree of liberalization in each member country. While there are many variations, the basic contrast is between a non-liberalized, regulated system, in which electricity generators are assured of cost recovery in electricity rates but only of incurred operating and capital costs, and a liberalized, deregulated system in which there is no assurance of cost recovery but generators can receive the market price of electricity regardless of their incurred costs. In the former more traditional regulatory system, the market value of freely allocated allowances would not be passed through to customers in electricity rates. The only CO_2 costs that could be recovered would be those of purchased allowances, and they would be offset by any revenues received from the sale of unneeded allowances. Nor would generators receive the wholesale market price of electricity, which could be higher or lower than their actual operating costs. In the deregulated version, the generator would receive the market price for electricity which will reflect the marginal cost of generation for that time and location, which in turn would be expected to include the market value of CO_2 allowances. Consequently, in member states with fully liberalized electricity markets the market value of allowances was included in wholesale prices regardless of whether these allowances were received for free or purchased. In the end, free allocation would not cause as much of an increase in electricity prices in a traditional regulated setting as in a more liberalized one. Nor would free allocation lead to an increase in generators' profits in the regulated system; in effect, the market value of the freely allocated allowances would be passed through to retail customers. Auctioning becomes attractive as a remedy because it would lead to similar increases in electricity prices regardless of regulatory regime and it would not increase the profits of power companies operating in liberalized markets. It would, however, increase electricity prices for regulated customers.

These differences in regulatory regime for the power sector create problems when liberalization proceeds at widely varying paces among the participants in a cap-and-trade scheme. In the EU and by 2005, the electricity sectors in some EU countries (e.g. UK, the Netherlands, and the Nordic countries) had achieved, or were close to achieving, full wholesale and retail electricity market liberalization. Generating plants earned all of their revenues in unregulated competitive wholesale power markets and their profitability depended on the difference between competitive wholesale market prices and their generating costs. In these countries, changes in wholesale market prices were reflected in retail prices relatively quickly because retail supply contracts typically had durations of only one or two years.

In other EU countries (e.g. France, Spain, and Italy), the liberalization process was slower and only partially complete. In these countries, "transition contracts" of one type or another committed generating companies for some period of time to supply various categories of retail consumers at regulated prices that did not reflect prevailing wholesale market conditions. Generators earned some of their revenues from these regulated transition contracts and some from sales in the competitive wholesale markets. Retail consumers with regulated transition contracts were insulated from changes in wholesale market prices, while those who had chosen to be served under competitive retail supply arrangements (typically industrial customers) were not.

This situation of variable and incomplete electricity sector liberalization meant that the distributional impacts of introducing CO_2 emissions prices into the market would vary greatly among member states and among suppliers within member states that had partially liberalized their electricity markets. In those with fully liberalized wholesale and retail electricity markets, generators and consumers would quickly realize the cost, price, and profit effects of CO_2 pricing or other changes in competitive wholesale market prices. In those member states where a significant fraction of the sector continued to be subject to regulatory arrangements that kept retail prices from fully adjusting to changes in wholesale market conditions, the impacts of CO_2 pricing on retail electricity prices and on generator profits were muted. Of course, since it was and is EU policy to fully liberalize electricity sectors over the next few years, the experience of those member states with liberalized electricity markets provided a preview to other member states of what they can expect when their electricity sectors are completely deregulated.

Conceptual Issues: Opportunity Costs and Windfalls

In retrospect, it seems evident that the effect of the EU ETS on wholesale and retail power prices and generator profitability when the electricity sector was being liberalized was not widely understood. This reflected limited understanding of both the consequences of electricity sector liberalization and of the most basic principles of competitive market "opportunity cost pricing." For example, the argument that "windfall profits" caused higher electricity prices reflects a misunderstanding of how competitive electricity markets work. It assumes incorrectly that competitive market prices would reflect the zero acquisition cost of freely allocated allowances instead of their opportunity cost.

Whether an electricity generator in a competitive market has received the allowances for free or not, the relevant consideration in making offers to sell electricity is the opportunity cost of using the allowance to cover emissions. Since every allowance used to cover emissions means the loss of the opportunity to sell that allowance, an opportunity cost is incurred and that cost is the foregone market price for allowances. Accordingly, whether allowances are distributed for free or through an auction will typically have no effect on market prices in competitive electricity markets, although it will affect individual supplier profitability.

Another conceptual difficulty concerns the definition of windfall profit and its relation to free allocation. Nuclear generators operating in liberalized electricity markets in Europe have benefited to the extent that the market prices for electricity have incorporated CO_2 costs, yet they received no allowances. Their higher profits could be seen as a windfall, but they are generally not seen as such perhaps because they result from the higher prices created by the carbon constraint and not from allocation policy.

Empirical Issues: Electricity prices, fuel costs, and CO_2 cost pass through

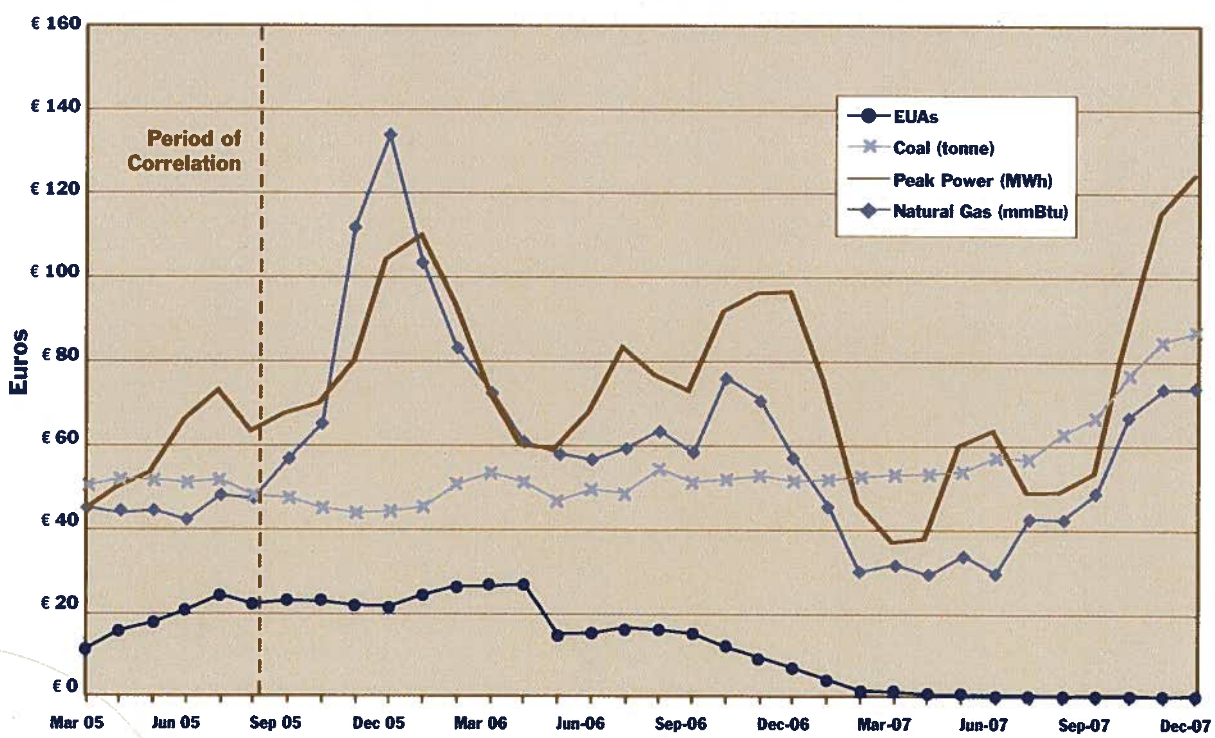
The increase in electricity prices that was experienced in Europe during the first year of the EU ETS imparted much impetus to the windfall profits controversy. Yet much of that price increase was due to increased fuel prices, as shown by Figure 6, which tracks the evolution of spot or near-term prices for coal, natural gas, CO_2 and electricity.

There was a brief period during the first seven months of 2005 (to the left of the dotted line in Figure 6) when electricity and EUA prices moved together. Electricity prices increased from about €40 per megawatt-hour (MWh) in early 2005 to €70 per MWh by the summer at the same time that EUA prices went from about €10 per metric ton to over €20, while fuel prices remained relatively unchanged. Thereafter, peak electricity prices rose to as much as €110 per MWh, but their movements were far more closely related to the price of natural gas than to that of EUAs. And since spring 2007, electricity prices have increased from €40 per MWh to over €120 per MWh in keeping with fuel costs and at a time when the CO_2 price has been insignificant.

Once the concept of opportunity cost is understood, the issue of how CO_2 allowance prices are "passed through" in the final prices for electricity or for other goods and services must be addressed. The extent to which allowance prices are reflected in the prices of final goods is a complicated matter even when markets are fully competitive. In theory, and in a perfectly competitive market, the marginal

Figure 6

Prices for Electricity, Coal, Natural Gas and EUAs 2005-2007



Source: Compiled by the authors from *Tendances Carbone*.

supplier that clears the market will pass through that supplier's full marginal (acquisition or opportunity) cost of allowances per unit of output. Infra-marginal suppliers will be affected in different ways depending on their CO_2 intensities and whether or not they must purchase allowances to cover their emissions. However, in real electricity markets, there are many conditions that can lead to more or less than full pass-through of marginal costs. Finally, to the extent the market is not perfectly competitive, the full carbon cost will not be passed through and some degree of previous oligopoly profit will be given up as firms adjust to the new cost circumstances.

Research conducted by Jos Sijm at the Energy Research Centre of the Netherlands and his collaborators finds that CO_2 costs have been passed through to wholesale electricity prices but that generators have not been able to recover the full market value of their free allocations. In a careful study of wholesale electricity markets in Germany, the Netherlands, Belgium and France from January through July 2005, Sijm et al. (2005) estimated that the average pass-through rates varied from 40 percent to 70 percent depending on the country and whether it was a peak or off-peak demand period.

Whatever the effect of CO_2 costs on wholesale electricity prices, the effect on retail customers depends on the degree of liberalization in retail markets. In many EU member states and for many customer categories, retail power prices continued to be regulated based on historical costs rather than wholesale market prices. For instance, in Spain, the increase in retail prices for regulated customer classes was limited to a set percentage increase and any greater cost incurred by generators for fuel or CO_2 allowances is booked as a regulatory asset to be recovered later. Moreover, the Spanish regulator has recently stated that companies would not be able to recover the opportunity costs of freely allocated allowances. And, in the UK, the regulatory authority has proposed that the market value of freely allocated allowances be recaptured by some means and used to help customers in fuel poverty. [21]

What can be generally said is that, for retail customers in many member states although not all, the higher wholesale prices resulting from CO_2 emissions costs have not been passed through. Large industrial customers are more likely to have faced retail prices reflecting higher wholesale electricity prices, although for these customers as well, much depends on the progress of market liberalization in each member state. Even so, as pointed out in a study on this subject conducted by the International Energy Agency (IEA, 2007), large industrial customers are often protected by long-term contracts and other financial means of hedging wholesale power price volatility.

Auctioning as the remedy

A commonly advocated remedy for windfall profits is auctioning allowances instead of allocating them freely to existing units (Sijm, Neuhoff, and Chen, 2006). This remedy would not cause electricity prices to be any lower, but it would end the granting of the scarcity rent associated with the free allocation of allowances to fossil generators. Advocates advance two main virtues of auctioning. It would ensure that carbon prices are passed through into retail prices where electricity markets have not been liberalized (thereby improving efficiency) and it would raise substantial revenue for the government that could be used for other purposes some of which could improve efficiency and equity. In opposition, it is argued that auctioning raises equity issues for suppliers who made investments when there were no constraints on CO_2 emissions and whose profits may be adversely affected by unanticipated carbon emission costs ("windfall losses"). If these suppliers are not compensated in some way, they are likely to oppose efficient market-based CO_2 emissions control mechanisms or to lobby for complicated tax credit, deduction, and other mechanisms to protect themselves.

Largely in response to the windfall profits critique, the European Commission has proposed, in the recently released draft amendments to the Emissions Trading Directive, that power generators receive no free allocations beginning in 2013 and that the allowances that would be otherwise allocated to them be auctioned by each member state. The prospective debate as these amendments go through the European co-decision process will provide a good view of the politics resulting from the distributional effects that flow from any significant constraint on CO_2 emissions. The issue of this debate, and of similar ones that will occur in the U.S. where auctioning all allowances is increasingly advocated, will reflect considerations of political economy. The best that economists can do is to focus on minimizing the adverse effects that political concerns can have on the efficiency of programs and on structuring programs that clearly separate distributional decisions from the efficient performance of the system. As pointed out by Stavins (2007), this is one of the chief merits of a cap-and-trade program and this result is achieved whether allowances are distributed by auction, free allocation, or a mix of the two.

In sum, the issues associated with windfall profits and the free distribution of emission allowances are more complicated than they are often presented to be. These issues have not arisen in U.S. cap-and-trade programs for SO_2 and NOx, in part because the effects on electricity prices are small (since emissions per MWh are considerably less for SO_2 and NOx) and the revenues to be received from auctioning much less than what would be the case in a CO_2 cap-and trade program.[22] It is likely that the same debate that has been occurring in Europe will take place in the U.S., not least because electricity sector liberalization has been implemented in only a third of the U.S. states with little prospect that it will spread (Joskow, 2006). As a result, the differing effects of allocation and auctioning decisions on a partially liberalized electricity sector are likely to be at least as contentious and complicated in the U.S. as they have been in Europe.

B. "Over-Allocation"

The release of the 2005 emissions data in April and May 2006 and the associated sharp fall in EUA prices created another controversy for the EU ETS: over-allocation. Like windfall profits, over-allocation is not a well-defined concept, but it is generally understood to mean that the member states created too many allowances during the trial period to the point even of creating a non-binding EU cap.

A non-binding cap was always a non-trivial possibility in the EU ETS during the trial period. The problem lies in caps that have modest goals for reducing initial emissions below business-as-usual (BAU) levels. A cap that is expected to be modestly constraining can become non-binding when the variation in BAU emissions, due to weather, economic growth and other factors and which can be as much as 5-10 percent, turns out to be on the low side. In this case, what was expected to be a modest shortage becomes a surplus. A similar outcome has recently been indicated as likely for the Regional Greenhouse Gas Initiative in the Northeast U.S. (Point Carbon, 2007), which like the EU ETS has a modest emission reduction goal.[23] Similar variations in BAU emissions occur in all cap-and-trade programs; however, when the reduction goal is more ambitious (50 percent or so), a downward variation in BAU emissions will have much less effect on prices and it will not create a surplus.

The modest ambition of the trial period with respect to emission reductions is explicit in the criteria used to determine member state totals. The Commission's guidance for submission of National Allocation Plans for the first period stipulated that the member state's cap be the lower of expected 2005-07 emissions (e.g., BAU emissions) or the member state's "Path to Kyoto," which was interpreted as a level of emissions that would not preclude the member state's achievement of its Kyoto commitment as modified by the European Burden Sharing Agreement (Zapfel in Ellerman, Buchner, and Carraro, 2007). In fact, member state totals in the trial period were more closely aligned with recent emission levels than with the Path to Kyoto.[24] At most, the *expected* emission reduction for the EU25 as a whole during the trial period was only one to two percentage points. This modest ambition and the uncertainty in any forecast necessarily implied a high probability that the aggregate cap during the trial period would turn out to be non-binding.

In addition to the modest ambition for emission reductions during the trial period, the difficulty of choosing an appropriate member state total was further compounded by a cluster of problems associated with data, sector definitions, and the use of projections. Setting a cap at or slightly below BAU emissions implies an ability to predict BAU emissions. Such predictions are necessarily uncertain, but when the projection concerns a sub-set of total emissions that has not heretofore been modeled carefully and for which no baseline data are readily available, the problem of defining a binding cap becomes almost insurmountable. In the event, installation data had to be assembled in great haste to meet the tight implementation deadlines and models had to be modified (or even created) to simulate the trading sectors and then calibrated on the hastily gathered and not always available baseline data. Even with good data and well calibrated models, there would have been errors, but those errors were greater because of the poor data and new sector definitions. Finally, the East European member states were continuing to undergo a structural transformation of their economies that made forecasting emissions even more difficult.

In retrospect, it is not surprising that some member states and sectors received allocations that were larger than their expected and actual emissions. Quite aside from obvious political pressures to increase allocations, establishing member state totals and an EU cap that was expected to be binding and that would turn out to be so during the trial period was an exceedingly difficult task. It is understandable that the Commission and the EU as a whole did not get it exactly right.

This problem will disappear with the second and post-2012 periods as the result of incorporating more aggressive emission reduction goals in the emission caps and having the benefit of verified emissions data for 2005 which the Commission has relied upon in determining second period member-state totals. All second period National Allocation Plans are now approved and the second period EU cap will be about 13 percent lower than the first period cap and 6 percent lower than comparable 2005 emissions. Table 3 provides the allocation data by member state with the EU25 ranked according to their first period caps.

Table 3

Comparison of Second Period Caps with First Period Data

Member State	First Period Cap (Mt)	2005 Emissions (Mt)	Second Period Cap[a] (Mt)	% below First Period Cap	% change from 2005 emissions
Germany	499.0	474.0	442.1	- 11.4%	- 6.7%
United Kingdom	245.3	242.4	206.7	-15.7%	- 14.7%
Poland	239.1	203.1	202.2[b]	- 15.4%	- 0.4%
Italy	223.1	225.5	195.8	- 12.2%	-13.2%
Spain	174.4	182.9	145.6	-16.5%	- 20.4%
France	156.5	131.3	127.7	- 18.4%	- 2.7%
Czech Republic	97.6	82.5	86.8[b]	-11.1%	+5.2%
Netherlands	95.3	80.35	81.8	-14.2%	+ 1.8%
Greece	74.4	71.3	69.1	- 7.1%	-3.1%
Belgium	62.1	55.6	53.5	-13.9%	- 3.7%
Finland	45.5	33.1	37.2	- 18.2%	+ 12.4%[d]
Portugal	38.9	36.4	34.0	- 12.5%	- 6.5%
Denmark	33.5	26.5	24.5	- 26.9%	- 7.6%[d]
Austria	33.0	33.4	30.4	- 8.0%	- 9.1%
Hungary	31.3	26.0	25.5[b]	- 18.6%	- 2.0%
Slovakia	30.5	25.2	30.8	+1.1%	+ 22.3%
Sweden	22.9	19.3	20.8	-9.2%	+ 7.8%[d]
Ireland	22.3	22.4	22.3	=	- 0.5%
Estonia	19.0	12.6	12.4[b]	-34.7%	- 1.7%
Lithuania	12.3	6.6	8.8[b]	-28.9%	+32.6%
Slovenia	8.8	8.7	8.3	- 5.7%	- 4.6%
Cyprus	5.7	5.1	5.5	- 3.9%	+ 7.5%
Latvia	4.6	2.9	3.4[b]	- 25.4%	+ 18.3%
Luxembourg	3.36	2.65	2.68	- 21.1%	+ 3.2%
Malta	2.94	1.98	2.1	- 28.6%	+ 6.1%
Romania[c]	74.8	70.8	75.9[b]	+ 1.5%	+ 7.2%
Bulgaria[c]	42.3	40.6	42.3[b]	=	+ 4.2%
EU15	1729.6	1637.0	1494.2	- 13.6%	- 8.7%
EU10	451.8	374.7	385.8	- 14.6%	+ 3.0%
EU25	2181.4	2011.7	1879.9	- 13.8%	- 6.6%
EU12	568.9	486.1	504.0	- 11.4%	+ 3.7%
EU27	2298.5	2123.1	1998.1	- 13.1%	- 5.9%

Source: European Commission, IP/07/1869, dated December 7, 2007.

Notes:

a. Excludes additional installations in second phase with 84.5 Mt of emissions of which the largest are 39.5 Mt in the UK, 11 Mt in Germany, 6.7 Mt in Spain, 6.3 Mt in Poland, 5.1 Mt in France, 5.0 in Belgium, and 4.0 Mt in the Netherlands.

b. Commission-approved cap is being contested in the European Court of Justice.

c. Romania and Bulgaria joined the EU and the EU ETS in 2007. The figures given for the first period cap are for 2007.

d. Favorable hydroelectric conditions in Scandinavia in 2005 and a two-month pulp and paper industry strike in Finland created unusually low 2005 emissions for Denmark, Sweden, and Finland.

The second period caps are as much as 25 percent to 35 percent lower than the first period totals for several countries, mostly in Eastern Europe, although these reductions reflected as much the error in estimation of BAU emissions in the trial period as they did a desire to impose emission reductions on the new member states. When compared to 2005 emissions, the new member states have been allowed a second period total that is almost 4 percent higher, whereas the EU15 total for the same period is almost 9 percent lower.

With an EU-wide cap 6 percent below 2005 emissions and another five years of economic growth from 2005, "over-allocation" is not expected to be an issue in the second period. Another reason for "over-allocation" to disappear as an issue is the proposed further 11 percent reduction in the third period (2013-20) cap and the availability of banking from the 2008-12 to the post-2012 period. With banking, the still tighter third cap will create demand that will tend to sustain the EUA price during the second period.

The over-allocation argument has had the unfortunate effect of implying that there has been no abatement during the trial period. In fact, the surplus that will exist ex post when the final accounting for 2007 is made will be larger by the amount of abatement that occurred when EUA prices were at levels that were considered high for most of 2005 and 2006. While the quantity of abatement during the trial period may not have been great, the early high EUA prices would have created an incentive for short run abatement behavior, in particular by the power sector.

Abatement is very hard to estimate because it involves the construction of a counterfactual estimate of what emissions would have been in the absence of the EU ETS. This counterfactual estimate should take into account actual economic growth, energy prices, and weather since all of these variables affect what emissions would have been absent a CO_2 price. Despite these difficulties, some analyses and estimates are starting to appear.

Ellerman and Buchner (2008) note that 2005 and 2006 emissions were lower than the historical baseline emissions used in the development of the first National Allocation Plans despite continuing economic growth in the EU and increases in oil and natural gas prices that could be expected to increase demand for coal-fired generation. Using a very simple counterfactual based on the extrapolation of pre-2005 emission trends and observed growth in economic activity, they conclude that abatement in 2005 and 2006 was "probably between 50 and 100 million tons in each of these years." This is between 2 percent and 5 percent of covered emissions.

Delarue et al. (forthcoming) provide a more rigorous estimate for the power sector alone of 88 million tons in 2005 and 59 million tons in 2006. Their estimate is based on a modeling simulation of the European power system using actual fuel prices and actual demand for fossil fuel-fired electricity generation. This simulation finds that the largest reduction occurs in Germany because of increased flows of power with lower emission rates from neighboring countries and switching from coal to natural gas fired generation within Germany.

In support of these tentative early research findings, the European Environmental Agency's latest release on EU GHG trends and projections (EEA, 2007) reports that CO_2 emissions from the public electricity and heat production sector were down on a year-to-year basis from 2004 to 2005 for the EU25 as a whole and that the largest source of reduction was Germany.

By its very nature, the trial period would not have led to significant abatement because the abatement goals were modest, allowance prices were expected to be low, and the duration of the trial period was too short to stimulate long-term investment to reduce CO_2 emissions. Still, a modest amount of abatement, perhaps as much as 5 percent, is likely to have occurred in 2005 and 2006. As we have already noted, the primary goal of the EU ETS during the trial period was not to effect significant CO_2 emission reductions, but to develop the cap-and-trade infrastructure that would reduce the cost and facilitate meeting the requirements of the Kyoto Protocol in 2008-12 and that would become the mechanism for more ambitious emission reductions in later periods.

C. The Allocation Process

The term allocation is frequently used in the EU ETS to refer to both cap-setting and the distribution of allowances by the member states to covered installations. This section discusses the latter aspect in which member states had to take into account a number of factors, such as different views about which sectors were in the best position to respond to CO_2 prices, the effects of CO_2 prices on industries that competed with suppliers in other countries inside and outside the EU, industry lobbying, and more generally contending definitions of what is fair and equitable. These distributive aspects of allocation found expression in controversies over benchmarking, harmonization, and auctioning.

"Benchmarking" refers to an allocation whereby installations would receive allowances according to some "benchmark" emission rate times an indicator of the installation's level of economic activity, typically either output or an input such as energy consumption. Benchmarking is typically advocated as a means of rewarding installations with relatively low emission rates and punishing those with comparatively high emission rates. Yet despite the vocal championing of this approach, benchmarking was rarely adopted in the National Allocation Plans for 2005-07. The two main reasons were the heterogeneity of production processes, which reflects differences in final product and local circumstance more than those in efficiency, and the lack of any convenient pre-existing standard that could serve as the benchmark.[25] With only a few exceptions, recent historical emissions provided the basis for allocation to individual installations for they had the merit of recognizing pre-existing differences in fuel use, efficiency, and utilization.

The just completed second round of National Allocation Plans for 2008-12 has seen more use of benchmarking, but almost entirely in the power sector and it still remains the exception. And, as if to emphasize the difficulty of agreeing on uniform product benchmarks, those adopted are typically fuel specific, that is, different for power plants generating electricity from natural gas and coal.

The term "harmonization" refers to the differences in allocation to similar facilities located in different member states. "Harmonization" was not an issue at the design stage of the trial period, but it became one as the results of the National Allocation Plans became evident. Producers on one side of an intra-EU border viewed competitors on the other side that had received a more generous allowance allocation with dismay and complained accordingly. The reasons for these sometimes significant differences in allocations to otherwise similar installations resulted from the different criteria for cap-setting among the member states, notably those originating in the European Burden-Sharing Agreement, and individual member state decisions on how to distribute their allowance total to installations, in particular how to allocate the expected shortage.

In evaluating claims of competitive distortion due to a lack of harmonization, a clear distinction needs to be made between allocation provisions concerning new entrants[26] and closures and those for incumbent facilities that operate throughout the trading period. Provisions that endow new or expanded facilities with allowances and force closed facilities to forfeit post-closure allowances will have distorting effects since they are contingent on actions that the owners of these facilities take (Ellerman, 2008). Investment in new or expanded capacity might change its location due to a more generous new entrant endowment in another member state. Similarly, a candidate for closure in one member state might stay open if its existing endowment is larger than that for an otherwise similar candidate for closure in another member state.

These distortions do not apply for the vast majority of incumbent installations that operate throughout the trading (and allocation) period and which would not close if they had to pay for their allowances. As noted earlier, the CO_2 cost is the same whether it is an opportunity or acquisition cost, that is, whether allowances are allocated freely or must be purchased. The market price for the goods produced by these installations and the operation of two otherwise identical plants will be the same regardless of how EUAs are acquired. Thus, the failure to harmonize has not had and would not have competitive or efficiency consequences. While operations and prices are not affected by allocation, profits are; and it is the unfairness of these financial effects that creates the demand for harmonization.

Many factors made it difficult to harmonize allocations across EU member states, but the overriding consideration is the political reality of the European Union: whether the constituent member states are willing to delegate the national decisions that created these differences to Brussels. Even if they are, complete harmonization is unlikely since differences in national circumstance, such as those between the West and East European member states, will likely lead to some differentiation of national burdens and resulting differences in allocations to individual installations. Fundamentally, harmonization and differentiation work at cross purposes for both involve distributional issues of equity. Setting aside the distortions due to the new entrant and closure provisions in the EU ETS, the underlying issues are not ones of competitiveness and efficiency.

Like benchmarking, auctioning has seen greater use in the second round of National Allocation Plans than in the first; however, the greater use of auctioning is still far short of what is allowed, not to mention what proponents advocate. Both the percentage of allowances auctioned and the number of member states choosing to auction have increased markedly from the first to the second trading period, although both remain small. Moreover, only one member state, Denmark, has chosen to auction the maximum percentage allowed by the EU Emissions Trading Directive (5 percent during the 2005-07 period and 10 percent during the 2008-12 period), but only for the first trading period.[27] The second period NAP process is nearly complete so that the member states choosing to auction and their percentages can now be presented in near final form.[28]

Table 4

Percent of Member State Allowances Auctioned

Member State	Percent of Cap Auctioned 2005–07	2008–12
Denmark	5.0	0
Hungary	2.5	2.3*
Lithuania	1.5	2.9*
Ireland	0.75	0.50
Austria	0	1.2
Belgium	0	0.3
Germany	0	8.8
Netherlands	0	4.0
UK	0	7.0
EU Total	0.13	3.0

Source: National Allocation Plans.
*Proposed but not finally approved

The allocation process as it has existed for both the first and second trading periods would be radically changed by the recently proposed amendments to the Emissions Trading Directive. In essence, the system would be drastically centralized. National Allocation Plans would be abolished; the EU-wide cap would be set centrally; a principle of 100 percent auctioning would be established; free allocation to the power sector would be abolished as of 2013; free allocation to all other sectors would begin at 80 percent of the 2008-12 level in 2013 and be phased out by 2020 with some exceptions if international trade problems can be demonstrated; the rights to auction and to receive the resulting revenue would be assigned to member states; and free allocations would be made by EU-wide rules that would be worked out by the Commission and the member states. This bold proposal would eliminate harmonization as a problem, make free allocation the exception, and presumably rely more on benchmarks than is presently the case. The fate of these provisions in the co-decision process over the next year or two will reveal much about the degree of centralization that can be achieved in a multi-national system, as well as the feasibility of EU-wide benchmarking, identifying trade-impacted sectors, and shifting rapidly to high levels of auctioning. For one thing, allocating auction rights among nations and deciding the use of auction revenues may prove no easier than negotiating caps among nations and allocating allowances to firms.

As this debate unfolds, it will be important to keep in mind that the decision to rely heavily on free allocations of allowances to address distributional concerns and associated issues of political economy may have been wiser than often viewed. If nothing else, free allocation facilitates getting a program to price CO_2 emissions up and running quickly, rather than spending years with affected interest groups fighting any program at all. As has been pointed out by Raymond (2003), fundamental principles of equity underlie allocation debates. In particular, deep issues concerning the competing claims of prior use and of higher public purpose are involved. Nearly all societies grant considerable deference to prior use claims, in this case to entities that had been freely exercising the right to emit prior to the implementation of the policy. And against these claims must be set those of public purposes that can be served by the value embedded in allowances—a value that is created not by private parties but by an act of government taken on behalf of society. Reconciling claims based on prior use and public purpose, not to mention the difficulty of distinguishing these claims from special interest lobbying, will never be easy or absent from the debate. The coming debate in Europe over the proposed ETS amendments will test these claims and reveal how easy it will be to decide the public purposes to which auction revenues should be devoted.

The criticism that allowance allocation is an impossibly sordid rent-seeking exercise often implies that the problem is avoided with auctioning or a carbon tax. Anyone who has examined revenue earmarks or the income tax codes will understand that the same forces apply. If an auction mechanism or emissions tax were chosen instead, an equally complex set of earmarks, credits, exemptions, and loop holes would emerge through the political process. Whatever the mechanism, any system that seeks to reduce GHG emissions will have broad distributive consequences, and it will create scarcity rents, as well as claimants for the allowances or revenues that have been created. CO_2 prices high enough to stabilize atmospheric concentrations of GHG at target levels around 550 ppm imply that the market value of CO_2 emissions in the EU or the U.S. amounts to hundreds of billions of dollars per year over the next 50 years (Paltsev et al., 2007). With that much money at stake, no one should be surprised that interest groups will lobby hard to influence decisions or that the political system will respond by mitigating distributional effects, whatever emissions control mechanism is chosen. The key policy challenge is to ensure that the mechanisms used to achieve distributional goals and to resolve political economy challenges do not distort abatement behavior or competition.

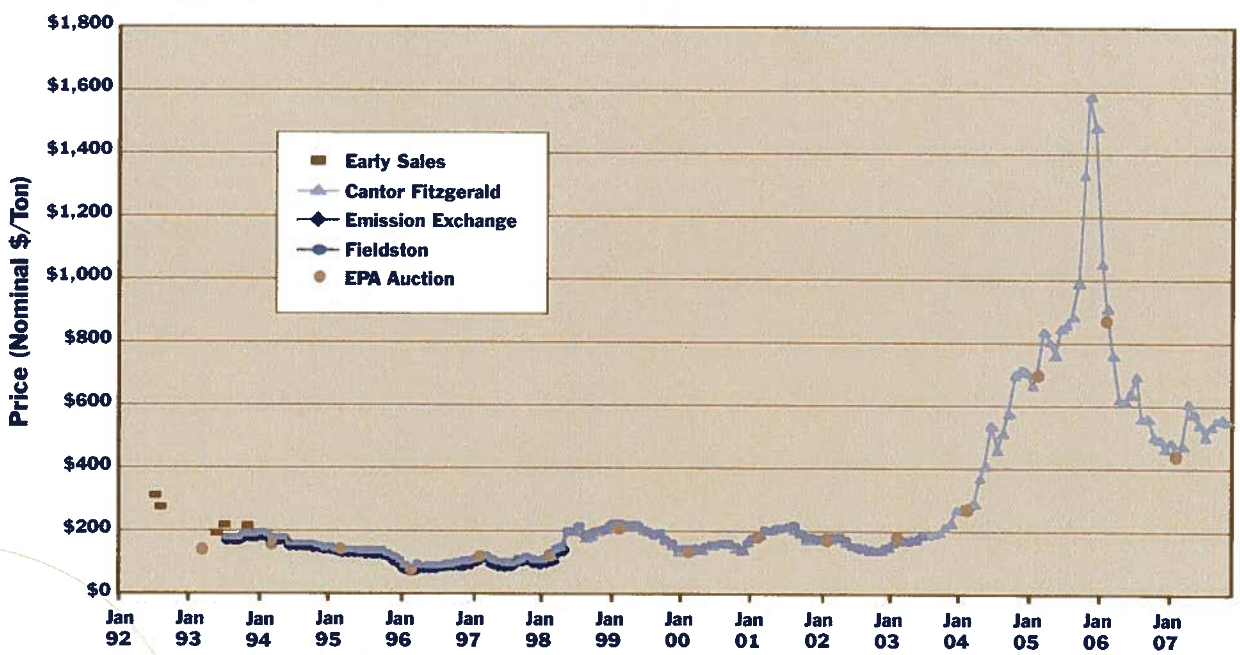
D. Price Volatility

The trial period of the EU ETS has experienced some dramatic allowance price movements. As shown in Figure 1, the allowance price tripled in the first six months, collapsed by half in a one-week period in April 2006, and declined to zero over the next twelve months. Such movements and the implied volatility inevitably raise questions about the effectiveness of allowance prices for providing reliable incentives for abatement and other changes in behavior that reduce the targeted emissions.

The price movements observed during the trial period's three-year duration are not unusual for cap-and-trade systems. The initial price of SO_2 allowances in the U.S. Acid Rain Program (~$130) was about half what was expected (~$250) and after the first two quarterly data releases in early 1995, the price halved again to an all-time low of $70 in early 1996 (Ellerman et al., 2000). The initial prices in both phases of the Northeastern NOx Budget Program also experienced large price spikes at the beginning of the initial ozone season in each phase of that program, which then quickly settled down

Figure 7

SO_2 Allowance Prices 1993-2007



Source: Various sources compiled by the authors.

to levels that were lower than what had been initially predicted (Aulisi et al., 2005). Moreover, price volatility is not limited to the start-up of these programs as evidenced by the evolution of U.S. SO_2 prices as shown in Figure 7.

The extraordinary SO_2 price increase of 2004 and 2005, long after the program began, makes all the earlier price fluctuations seem modest. The steady increase in price in 2004 reflected both the final regulatory decisions on the Clean Air Interstate Rule, which will reduce the SO_2 cap by one-half in 2010 and by another third in 2015,[29] and a concomitant rise in the domestic premium paid for low sulfur steam coal due to a metallurgical and export coal boom. Still this does not explain the extraordinary late 2005 price spike, which also coincided with a sharp rise in natural gas prices. The large bank of allowances should have moderated this price excursion unless it was expected to be permanent, which seems unlikely given the known volatility of natural gas prices and the considerably lower cost of scrubbing.[30]

In the EU ETS, the volatility of the prices for first period allowances was exacerbated by the restriction on trading between the first and second periods. Most obviously, if there had been no restriction on banking between the trial and second period, the price for CO_2 for most of 2007 would not have been effectively zero because the price difference between first and second period allowances would have been arbitraged away. Also, both first and second period prices fell significantly when the verified emissions data were released in April 2006, but the inability to bank caused the first period price to fall by more than the second period price (a reduction of 50 percent vs. 30 percent). This release of relevant information provided a common reliable basis for calibrating price expectations for both what remained of the first period and the second period. In sum, the banking restriction caused first period prices to fluctuate more than would otherwise have been the case.

Furthermore, annual reporting compounded the effects of the self-contained three-year trial period creating the greater volatility of first period EUA prices. Almost half of the trading period had elapsed before the first release of emissions data was available, and that left little time to adjust by increasing emissions and less opportunity for unpredictable but compensating weather or energy price developments to create demand before the end of the period. Had it been possible to report emissions data on a quarterly basis, as is done in the U.S. SO_2 and NOx programs, the initial calibration of expectations would have occurred earlier, there would have been more time to adjust to the new information, and the surprise would have been smaller.

Despite these factors, the volatility of EUA prices and of allowance prices generally has been comparable to that of related energy commodities as shown in Table 5.

The volatility is measured in the standard way as the expected variation in price over a year's time. For all the series except SO_2, the data points given in the ranges are annual volatility calculated over quarterly observation periods from the beginning of 2005 through the first quarter of 2007. The SO_2 values are annual volatilities calculated annually for 1995 through 2006. The December 2006 futures contract is chosen to represent first period prices because it includes the price drop in April-May 2006 while excluding most of 2007 when the near zero prices for the December 2007 contract and for spot transactions resulted in artificially high volatility indicators.[31]

Table 5

Volatility of Selected Commodities

Commodity	Volatility Range in % 2005-2007
EUAs Dec 06 futures	27–161 (57)
EUAs Dec 08 futures	28–91 (62)
SO_2 spot price (1995-2006)	8–44
Natural Gas (Zeebrugge)	55–138
Crude Oil (Brent)	24–32
Coal (ARA)	8–22
Baseload Electricity (Powernext)	35–96
Peak Electricity (Powernext)	42–105

Source: Mission Climat, Caisse des Depots.

NOTE: The figure in parentheses for the two EUA products is the highest observed volatility when the second quarter of 2006 is excluded.

The effect of the inter-period banking constraint can be seen again in the comparison between the volatility measures for the 2006 and 2008 EUA maturities. The banking constraint created more than half again as much volatility in the second quarter of 2006 for the trial period allowances (161 percent vs 91 percent for second period allowances). Outside of this quarter, the volatility of the two contracts was similar.

These data show that, except when the first period price movements of April 2006 are included, the volatility of EUA prices is no greater than that dealt with regularly in natural gas and electricity markets. Participants in all these markets can hedge their forward positions if they desire to protect themselves against adverse price fluctuations. This is commonly done in other commodity markets and the instruments to do so are available in the EU ETS and in most allowance markets.

E. Linkage

Linking refers to any use of credits or allowances from outside the system for compliance, that is, the use of anything other than the system's own allowances. In the case of the EU ETS, the primary source of such offsets are the project credits created under the Kyoto Protocol's Clean Development Mechanism (CDM), and known as certified emission reductions (CERs). The Linking Directive, enacted soon after the Emissions Trading Directive, opened the door to the use of CERs and Joint Implementation credits created by a similar process under the Kyoto Protocol.

Linkage provisions, such as those in the EU ETS are widely recognized as desirable in order to exploit lower cost mitigation options wherever they are located. Since there is no necessary relationship between individual country emissions caps and the geographic distribution of low-cost mitigation opportunities, mechanisms must be found to facilitate the ability of countries with relatively high-cost mitigation options to exploit relatively low-cost mitigation opportunities in other countries. Offsets and other linkage mechanisms provide the means to do so by making it possible for one country (or sources within a country) to get credit for mitigation investments made in another country.

The possibility of linkage has not had any practical importance in the trial period of the EU ETS because 1) the registry link that would enable the use of CERs was not expected to be in place until mid-2007, 2) the supply of pre-2008 CERs was never expected to be large, and 3) the bankability of these credits made their use in the trial period uneconomic as soon as the price disparity between first and second period allowances emerged. Still, the prices offered in the EUA allowance market in 2005 and 2006 and for second period allowances since then have provided a strong stimulus to CDM project development, increased the prospective supply of CERs, and made their use an important supplementary means of compliance for the second period. Finally, as issues concerning registry links and certification by the CDM's Executive Board have been resolved in the course of 2007, a sufficiently large secondary CER market has developed that generally recognized price quotes have been available since the summer of 2007.[32]

Linkage provisions are not without controversy. In general, linkage can have distributional impacts that create losers as well as winners (Jaffe and Stavins, 2007). A more commonly cited problem is "additionality," that is, ensuring that the credited reductions would not have taken place for other reasons thereby creating what has been called "anyway tons" in the United States. This is an always difficult issue for which there is no perfect answer but only methods of assessment that can be applied to ensure that a large part, if not all, of the credited reduction is real. In the case of the EU ETS, this job has effectively been delegated to the bodies and procedures established under the Kyoto Protocol. While controversy about CDM projects remains, there are at least as many complaints about the rigor with which credit certification criteria are applied as there are about the laxness or inappropriateness of some decisions and categories.

A second controversial feature of linkage is the concern about an oversupply of CERs in the 2008-12 period. While the likely supply and demand of these offsets can be debated, the EU ETS has taken measures to guard against over-supply by adopting quantitative limits on the extent to which off-system credits can be used: about 13 percent of the second period allocation. Finally, this particular worry should disappear as a result of the recently proposed amendments to the ETS Directive. Unused authority to import credits during the second trading period can be carried over into the post-2012 period, but the limits in that period are foreseen as being lower (along with a lower cap) and subject to the negotiation of an international agreement or, in its absence, bilateral agreements with the EU. Although not formally stated, the clear intent is to signal to host countries that projects cannot last forever and that continued access to the EU market will require "graduation" to assuming emission reduction responsibilities and the creation of broader sector-level or national cap-and-trade systems that could link to the European or broader international system through mutual recognition.

V. Conclusion: The EU ETS in Perspective

Views about the EU ETS have been heavily influenced by a misunderstanding of what the 2005-2007 trial period was supposed to achieve and the limited goals for emissions reduction that were incorporated into the trial period caps. The primary goal of the trial period was to develop the infrastructure and to provide the experience to enable the successful use of a cap-and-trade system to limit European GHG emissions in 2008-12 and beyond. The 2005-2007 trial period was never intended to achieve significant reductions in CO_2 emissions in only three years. In light of the speed with which the program was developed, the many sovereign countries involved, the unexpected increase in natural gas prices affecting a partially liberalized electricity sector, the need to develop the necessary data and compliance procedures, and the lack of extensive experience with emissions trading in Europe, we think that the system has evolved surprisingly well.

Although there have been plenty of rough edges, a transparent price on tradable CO_2 emission allowances emerged as of January 1, 2005, a functioning market in allowances has developed effortlessly without any prodding by the Commission or member state governments, the trading infrastructure of markets, registries and monitoring, reporting and verification is in place, and a significant segment of European industry is incorporating the price of CO_2 emissions into their daily production decisions. The proof of the value of this experience will be seen as the just begun second trading period progresses. So far, all indications are that the trial period accomplished its goal. The EU ETS has evolved from being an engaging possibility in the 2000 Green Paper (EC, 2000) to being what is now regularly characterized as the flagship of the European Climate Change Program.

The EU ETS is also interesting because it provides some insights into the problems to be faced in constructing a global GHG emission trading system. This will be the next stage in global climate diplomacy if and when the U.S. adopts a cap-and-trade system. In imagining a multinational system, it seems clear that participating nations will retain significant discretion in deciding tradable national emission caps albeit with some negotiation; separate national registries will be maintained with some arrangement for international transfers; monitoring, reporting and verification procedures will be administered nationally although necessarily subject to some common standard; and it seems doubtful that internal allocations will be "harmonized." As the world moves to develop and to link GHG trading systems, challenges similar to those characterizing the EU ETS will have to be confronted.

The deeper significance of the trial period of the EU ETS may be that its explicit status as a work in progress is emblematic of all climate change programs. Even when not enacted in haste, climate change programs will surely be changed over the long horizon during which they will remain effective. The trial period demonstrates that everything does not need to be perfect at the beginning. In fact, it provides a reminder that the best can be the enemy of the good. And this adage is likely to be especially applicable in an imperfect world where the income and wealth effects of proposed actions are significant and sovereign nations of widely varying economic circumstance and institutional development are involved. The initial challenge is simply to establish a system that will demonstrate the societal decision that GHG emissions shall have a price and to provide the signal of what constitutes appropriate short-term and long-term measures to take in limiting GHG emissions to the desired amounts. In this, the EU has done more with the ETS, despite all its faults, than any other nation or set of nations.

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Endnotes

1. Matters falling within EU jurisdiction are decided by a process that requires approval by both the Council of Ministers, representing the member states, and the European Parliament, whose members are elected by party slates presented to the citizens within each of the member states.

2. With the addition of Romania and Bulgaria in 2007, there are now 27 member states in the EU. There were 25 when the EU ETS began in 2005 and during most of the development of the enabling legislation, there were 15 member states (EU15).

3. In the case of an international agreement, the EU has committed to a 2020 reduction of 30 percent from the 1990 GHG emission level.

4. More specifically, the 1.74 percent factor would be calculated from the 2008-12 cap, starting in 2010 so that it would arrive at a 2020 level that is 21 percent below 2005 verified emissions in the EU ETS. When averaged over the proposed eight years, the third trading period cap would be about 11 percent lower than the second period cap, which is about 6 percent lower than 2005 verified emissions. The European Council goal concerns all GHG emissions in relation to 1990 levels while the proposed ETS amendments concern only CO_2 emissions within the trading sectors.

5. In 1998, the EU15 adopted a Burden Sharing Agreement (EU Council, 1998) that redistributes their uniform assigned amounts under the Kyoto Protocol of 8 percent below 1990 levels in a manner that takes differences in national circumstances into account. This redistribution ranges from + 27 percent for Portugal to – 28 percent for Luxembourg. (See also the discussion in chapter 2 of Delbeke (ed.)., 2006)

6. In addition to CO_2, the Kyoto Protocol includes emissions of methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

7. These sectors are iron and steel, cement and lime, refineries, pulp and paper, ceramics, glass, bricks and tile.

8. The annual emissions associated with this capacity threshold could vary from very little to as much as 40,000 metric tons for a coal-fired plant operating 75 percent of the time. The recently proposed amendments to the EU Emissions Trading Directive would change this threshold to allow installations with annual emissions less than 10,000 tons for three consecutive years to opt-out of the system provided certain other conditions are met.

9. There is no formal ban on banking between the trial period and the second trading period. This decision was left to the member states and all except France and Poland decided not to allow banking. Nevertheless, the Commission's statement of its assessment methodology for the review of the second period National Allocation Plans effectively negated these provisions by requiring that any banked EUAs be deducted from the second period cap.

10. Credits that are created outside of the flexibility mechanisms of the Kyoto Protocol, such as Verified Emission Reductions, cannot be used for compliance.

11. This amount is the greater of 10 percent or a percentage calculated by taking half of the largest disparity observed between the member state's Burden Sharing target and either the Kyoto baseline emissions (generally 1990), observed 2004 emissions, or the Commission's most recent projection of 2010 emissions for the member state.

12. For ease of expression and following common usage, member state totals are equivalently referred to as "caps." It must always be understood that these member state totals do not impose an absolute limit on emissions in any member state since the tradability of allowances issued by any member state is fundamental to the EU ETS. The only absolute limit is at the EU level and even there the Linking Directive would allow emissions to exceed the EU cap if properly offset.

13. A regulation is the strongest legal instrument in the EU in that it applies verbatim and does not allow for national interpretations.

14. For instance, per capita income for the richest member state of the EU (Ireland) is five times that of the poorest (Romania and Bulgaria) while the difference is only a factor of two in the U.S. (between Connecticut and Mississippi). In this comparison, the still higher income levels of Delaware and Luxembourg are not considered because of the small populations and tax-motivated concentration of corporate and financial activity in each.

15. In January 2008, Slovakia withdrew its challenge barely a month after the Commission granted a slight increase in its allowed total, although still far below the initial Slovakian proposal.

16. The 2007 data became available in April 2008 after the writing of this paper.

17. This is not to say that the two periods are hermetically sealed. CERs that are available by early 2008 could be used for first period compliance, but they are also bankable. With a price spread of nearly twenty euro between first and second period prices, all CERs available at the end of 2007 were banked for use in the second period. Also, economic possibilities to move the production of CO_2 intensive goods into the end of 2007 and to build inventory for sale in 2008 were exploited, as were opportunities to shift hydroelectric generation that would have otherwise occurred in late 2007 into early 2008.

18. The author of this typical but ill-timed example noted that the switching price was about €50 and that unless oil prices fell below $45 a barrel, "2008 allowances at €30/tonne may be quite a bargain."

19. The main distinction between OTC and exchange trading concerns guarantees of delivery and payment. Bilateral transactions, which may be arranged through the intermediary services of a broker, depend heavily upon the reputation of the contracting parties for assurance of delivery and payment. Exchanges are organized to guarantee payment and delivery to sellers and buyers who can then operate separately without knowing the identity or caring about the reputation of the counterparty.

20. Units which are long or short in one year tend to be so in the next year. Approximately 1900 installations or 21 percent were short in both years and 5700 installations (63 percent) were long in both years. Of the approximately 1450 installations that changed net positions between the two years approximately half went from being long to short and the other half, the opposite. The correlation coefficient for installation net position between the two years is +0.85.

21. Cf. "Spanish Parliament backs windfall profit tax on phase two EUAs" *Carbon Market Europe*, January 4, 2008, p. 5, and "UK energy regulator says utility windfall profit should go to poor customers" *Carbon Markiet Europe*, January 18, 2008, p. 4.

22. The total allowance value created by the SO_2 program is currently less than a tenth that of the EU ETS, or what is likely to be the value created by a U.S. GHG cap-and-trade program. At current prices of about €20 per metric ton, the value created by the EU ETS's annual cap of about 2 billion tons is approximately €40 billion per year, or about U.S.$60 billion at the current exchange rate. The value implied by a U.S. GHG system that is comprehensive (about 6 million short tons) and clears at a price of $10/ton is comparable. In contrast, the total value of the allowances created by the approximately 9 million ton SO_2 cap is about U.S.$4.5 billion at current allowance prices of about $500.

23. Although the potential for over-allocation has been emphasized in news reports concerning the Point Carbon study, the real message of that study is that the annual variability of emissions in the Northeastern U.S. is very high in relation to the cap and the expected reduction of emissions. The recent downward variation in emissions, experienced subsequent to the setting of the RGGI cap, has made the potential over-allocation evident.

24. A good example is provided by Spain. Its level of baseline emissions (2002-03) was already some 20 percent above its Kyoto/Burden Sharing Agreement target (which was itself 15 percent above 1990 emission levels), but its approved total for the trial period was about 5 percent above the 2002-03 level. Given Spain's rapid economic growth and accompanying increase of emissions, a target 5 percent above the 2002-03 level was expected to be less than actual emissions. As such, it was interpreted as heading towards the Path to Kyoto, if not being on it.

25. In the U.S. SO_2 and NOx trading programs, installation-level allocations are "benchmarked," not because the heterogeneity of production processes is any less but because of the existence of pre-existing standards of considerable institutional and legal force that could serve as the benchmark: the New Source Performance Standards established under various provisions and further regulatory implementation of the Clean Air Act Amendments of 1970. An accepted, pre-existing standard for CO_2 does not exist either in Europe or the United States.

26. Although the term "new entrant" is widespread, it refers to capacity not the owner of the new capacity. Most of the new or expanded facilities are built by existing companies.

27. Denmark's decision not to auction in the second period is explained mostly by the 27 percent reduction in its second-period cap compared to the trial period. In effect, one-fifth of that reduction was taken from the auction and the rest from the free allocation to installations.

28. It deserves note that Norway, which has been linked to the EU ETS since January 1, 2008, has been allowed to auction about half of its allowances instead of having to observe the 10% limit on auctioning that is imposed on the 27 member states of the EU during the 2008-12 period. Norway's high level of auctioning reflects the inclusion in the Norwegian cap of the Norwegian off-shore oil industry that had previously been subject to a $50/ton tax on CO_2 emissions.

29. The tightened SO_2 cap is not related to the acid rain problem that motivated the original SO_2 cap-and-trade program. Instead, states have been offered the opportunity, and they have chosen, to use the existing cap-and-trade infrastructure to meet SO_2 emission reduction requirements motivated by concerns about the effects of micro-particulate emissions on human health.

30. A similar extreme upward price excursion occurred in the Los Angeles NOx RECLAIM Program in late 2000, when the price of allowances went from about $5,000/ton to a peak reported price of more than $70,000 in the space of a few months (Harrison, 2004; Ellerman, Joskow and Harrison, 2003). The causes of this price spike have been well studied and are well understood (Joskow and Kahn, 2002). The absence of banking or borrowing in the RECLAIM program and its very limited geographic scope prevented any supply side adjustment when the California electricity crisis of 2000 placed unprecedented demands on old and little used gas-fired peaking units in Los Angeles with no emissions controls.

31. Fluctuations of a few euro cents around an average price of less than €0.10, as has been the case for much of 2007, will yield very high volatility measures.

32. Secondary CERs are deemed to be virtually equivalent to EUAs in that project and certification risk has been resolved. The primary market refers to CERs from projects that are in an earlier stage of development and still bear these risks.

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This report evaluates the initial trial phase of the EU Emissions Trading System and provides lessons for the EU moving forward as well as for the development of cap-and-trade programs in the United States. The Pew Center on Global Climate Change was established in 1998 in order to bring a new cooperative approach to the debate on global climate change. The Pew Center continues to inform the debate by publishing reports in the areas of policy (domestic and international), economics, environment, and solutions.

Pew Center on Global Climate Change
2101 Wilson Boulevard
Suite 550
Arlington, VA 22201
Phone (703) 516-4146
www.pewclimate.org

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Regional Cap-and-Trade Programs

WHAT IS HAPPENING ON THE REGIONAL LEVEL AND WHY IS THIS SIGNIFICANT?

Twenty-three U.S. states and four Canadian provinces are actively participating in the design and implementation of three regional cap-and-trade programs to reduce greenhouse gas emissions. Participating U.S. states account for one-half of the U.S. population, and Gross Domestic Product (GDP), and one-third of all U.S. greenhouse gas emissions. The Canadian provinces account for more than three-quarters of the Canadian population and GDP, and nearly one-half of Canadian GHG emissions.[1,2,3,4] These efforts are formally observed by another 14 states and provinces across the United States, Canada, and Mexico.

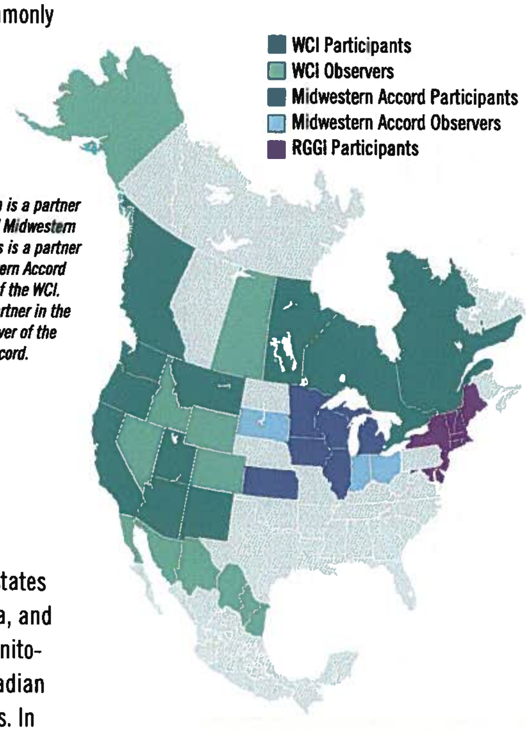
Regional cap-and-trade programs account for the most significant domestic greenhouse gas regulatory efforts to date. In developing these programs, the regions have demonstrated innovation about policy design and program implementation that will inform national climate policy development in the United States and Canada.

WHAT ARE THE REGIONAL PROGRAMS, AND WHICH STATES ARE PARTICIPATING?

The **Northeastern Regional Greenhouse Gas Initiative**, or **RGGI**,[5] was the first cap-and-trade program for greenhouse gases in the United States. It covers 10 Northeastern and Mid-Atlantic states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont). The program limits – or "caps" - carbon dioxide (CO_2) emissions from large fossil-fuel-fired electric generating units, with the goal of stabilizing emissions from 2009 through 2014 to a level roughly equivalent to recent historical emissions. The program then reduces the cap by 2.5 percent per year over the next four years so that in 2018 there is a 10 percent reduction from the baseline. RGGI took effect and began regulating CO_2 emissions on January 1, 2009. The first auction for allowances was held on September 25, 2008, and subsequent auctions have been and will be held quarterly.

The **Western Climate Initiative**, or **WCI**,[6] covers seven U.S. states (Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington) and four Canadian provinces (British Columbia, Manitoba, Ontario, and Quebec). Another six U.S. states, one Canadian province, and six Mexican states are formally observing this process. The WCI released a design document laying out its basic program parameters in September 2008. That agreement calls for a program that will cover nearly 90 percent of the region's greenhouse gas emissions when it is fully implemented (commonly referred to as an economy-wide program). The program will reduce emissions 15 percent below 2005 levels by 2020. Member jurisdictions are moving forward with program implementation. The cap-and-trade program will begin regulating emissions in January 2012. To ensure the program is founded on sound emissions data, mandatory emissions monitoring will commence in January 2010.

The **Midwestern Greenhouse Gas Reduction Accord**, or **Midwestern Accord**,[7] covers six U.S. states (Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin) and one Canadian province (Manitoba). Another three U.S. states and one Canadian province are formally observing this process. In early 2008, participating jurisdictions appointed an Advisory Group comprised of representatives from environmental groups, industry, and the participating jurisdictions to develop recommendations on a regional cap-and-trade program. In May 2009, the Advisory Group released their draft final design recommendations. These recommendations call for an economy-wide program that would reduce emissions 20 percent below 2005 levels by 2020, and 80 percent below 2005 levels by 2050, though the 2020 target may decrease to 18 percent if allowance prices escalate too high. The Advisory Group will meet to finalize its recommendations after regional economic modeling is completed in early fall 2009. A model rule, which is the sample rule upon which participating jurisdictions base their own rules, is being developed, and the Midwestern Accord cap-and-trade program is scheduled to launch in January 2012.



Note: Manitoba is a partner in the WCI and Midwestern Accord. Kansas is a partner in the Midwestern Accord and observer of the WCI. Ontario is a partner in the WCI and observer of the Midwestern Accord.

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NMED-LITZ
EXHIBIT 5

	RGGI	WCI	Midwestern Accord
Participants	**USA:** CT, DE, MA, MD, ME, NH, NJ, NY, RI, VT	**USA:** AZ, CA, NM, MT, OR, UT, WA **CAN:** BC, ON, MB, QC	**USA:** IL, IO, KS, MI, MN, WI **CAN:** MB
Program Status	Emissions covered beginning Jan 2009. First auction held Sept 2008.	Will commence Jan 2012. Released design document in Sept 2008 containing agreed-upon program parameters. Model Rule under development.	Will commence Jan 2012. Draft final recommendations released May 2009. Will finalize recommendations after regional economic modeling completed summer 2009. Model Rule under development.
Program Scope	**Gases:** CO_2 emissions. **Sources:** Large electric generators. **Coverage:** 28% of CO_2 emissions.	**Gases:** All 6 Kyoto gases. **Sources:** In 2012 — electricity generators and large industrial sources. In 2015 — expanded to emissions from residential, commercial, and other industrial combustion, and transportation fuels. **Coverage:** In 2012 — 50% of emissions. In 2015 — nearly 90% of emissions.	**Gases:** All 6 Kyoto gases. **Sources:** Economy-wide including: electric, industrial, residential, commercial, transportation combustion, and industrial process emissions. Manitoba will phase-in coverage in manner similar to WCI. **Coverage:** Roughly 85% of GHG emissions. Disparity in coverage between Midwestern Accord & WCI is primarily due to differences in regional sectoral emissions portfolios.
Reduction Targets	2009–2014 cap set at level roughly equal to historical emissions. 2015–2018 cap declines 2.5% per year, resulting in 10% reduction from 2009 budget.	Regional average reduction of 15% below 2005 levels by 2020 (jurisdiction targets vary).	20% below 2005 levels by 2020 (may decrease to 18% if allowances released from cost containment pool). 80% below 2005 levels by 2050.
Offset Usage Allowed	50% emissions reduction from BAU projections, which is equivalent to 3.3% of compliance obligation. More offsets allowed if allowance prices rise above price thresholds.	No more than 49% of emissions reductions relative to starting cap.	20% of compliance obligation. May expand if allowance prices rise above price thresholds. Note, price thresholds not yet determined.
Auction Goals	25% of allowances are allocated for consumer benefit or strategic energy purpose. Auctions were envisioned to be primary tool for this. As states began to implement RGGI, use of auction increased. Now, over 85% of the region's allowances will be auctioned in the early stages of the program.	10% auction minimum at start. Increase to 25% minimum by 2020. Aspirational goal of 100%.	May vary jurisdiction to jurisdiction. The Advisory Group recommended the following: 100% of transportation and merchant generator allowances, unless entity demonstrates inability to pass through costs. Initially 5% of industrial sector and 10% of electric sector allowances auctioned, remaining industrial and electric sector allowances sold to covered entities for a "modest fee." This equates to an auction of about 1/3 of all allowances and sale of the remaining 2/3. The Advisory Committee recommended a shift to a full auction over time.
Use of Allowance Value	Varies jurisdiction to jurisdiction. To date, majority of auction revenue directed towards energy efficiency programs.	Not established in September design document.	May vary jurisdiction to jurisdiction. The Advisory Group recommended that allowance value go towards: (1) accelerating transformational investment in technologies and infrastructure (2) cost mitigation for end-users, particularly low-income consumers and energy intensive industry (3) adaptation
Cost Containment	3-year compliance period with unlimited banking, early action credit, offsets, and price triggers. First price trigger expands use of offsets to 5% of facility compliance obligation. Second price trigger expands use of offsets expand to 10% of facility compliance obligation, increases the compliance period, and allows facilities to use international offsets.	3-year compliance period with unlimited banking, early action credit, and offsets.	3-year compliance period, unlimited banking, limited borrowing, early action credit, offsets, and price thresholds. Market Oversight and Cost Containment (MOCC) Committee will establish upper and lower price thresholds. If prices are too high, allowance borrowing and offset limits will be expanded. If prices are too low, allowance borrowing will be curtailed and offset limits tightened. If allowance prices substantially exceed the price threshold, allowances will be released from a reserve pool. If allowance prices are extremely low, the MOCC will withdraw allowances from the market and put them in the reserve pool.

Notes

1. Climate Analysis Indicators Tool. WRI. http://www.cait.wri.org
2. U.S. Census Bureau. http://www.census.gov/
3. Statistics Canada. http://www.statcan.gc.ca/
4. Environment Canada. Canada's Greenhouse Gas Inventory. http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm
5. http://rggi.org/
6. http://westernclimateinitiative.org/
7. http://midwesternaccord.org/
8. This chart was compiled by WRI with contributions from the Pew Center on Climate Change

For additional information on regional programs, please contact Nicholas Bianco at nbianco@wri.org, or 202-729-7715.